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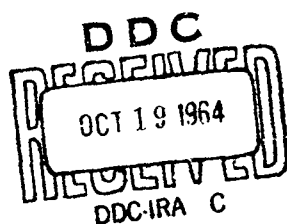


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Report No. II (2nd Annual)
Contract: DA19-129-DM-2050
University of Georgia

**STUDY OF THE STORAGE STABILITY
OF
CONTAINERS AND FOOD PROCURED
FOR THE
CIVIL DEFENSE SHELTER PROGRAM**

Period Covered:
21 June 1963 - 20 June 1964

U. S. ARMY NATICK LABORATORIES
NATICK, MASSACHUSETTS



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<p>AD Georgia Experiment Station, Experiment, Ga. STUDY OF THE STORAGE STABILITY OF CONTAINERS AND FOOD PROCURED FOR THE CIVIL DEFENSE SHELTER PROGRAM S. R. Cecil and J. G. Woodroof</p> <p>Report No. II, 16 July 64, 67 pp, 16 tables (Contract DA-19-129-QM-2050(N)) DA Proj 2210.8 Unclassified Report</p> <p>Progress is reported on storage of: (1) 2 production contract lots of bulgur wafers and 1 of survival biscuits for 6 & 12 months, (2) 2 lots of survival biscuits for 12 months, (3) 3 lots of crackers and 2 of biscuits for 12 & 18 months, including (a) bursting strength, moisture, and general condition of V3c fiberboard cases, (b) corrosion, coating defects, leakage, and headspace oxygen of 2 1/2-gal. and 5-gal. metal cans, and (c) wrapper and product damage, color, fracture strength, moisture, peroxide values, free fatty acids, sensory quality and hedonic ratings of the food. Initial examination of 3 lots of Carbohydrate Supplement is also reported. Storage conditions were 100°F/80% r.h., 100°F/57%, 70°F/80%, 70°F/57%, 40°F/57%, and 0°.</p>	<p>UNCLASSIFIED 1. Civil Defense shelter 2. Contract DA-19-129-QM-2050(N)</p>
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CONTRACT RESEARCH PROJECT REPORT

U. S. ARMY NATICK LABORATORIES
NATICK, MASSACHUSETTS 01762

University of Georgia
Georgia Experiment Station
Food Processing Division
Experiment, Georgia

Project No. 2210.8
Contract DA 19-129-QM-2050(N)

Report No. II (2nd Annual)

Official Investigator:
J. G. Woodroof

Period: 21 June 1963-
20 June 1964

Project Leader:
S. R. Cecil

Initiation Date: 21 June 1962

Title of Contract:--Study of the Storage Stability
of Containers and Food Procured for the Civil
Defense Shelter Program.

Summary

Annual Report #II includes results of examination of stored
shelter rations as follows:

<u>Codes</u>	<u>Products</u>	<u>Storage Periods</u>
CD1, CD5	survival crackers	12 and 18 months
CD2	survival cracker	6 and 12 months
CD3, CD4	survival biscuits	12 and 18 months
CD6, CD7	survival biscuits	12 months
CD9	wafer, bulgur, white	6 and 12 months
CD10	wafer, bulgur, red	6 and 12 months
CD11, CD12, CD13	carbohydrate supplements	initial

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2210.8 #II

I. Fiberboard Cases. Examinations from storage utilized one case of each product from each room. Three cases of each carbohydrate supplement were examined initially, including cases damaged in shipping; the remaining 54 cases of each carbohydrate supplement were acceptable for storage, dated 27 March 1964.

I.1. Bursting strength of fiberboard exhibited a tendency to decrease at 100°F, the 10 cases from 80% r.h. averaging 70 lbs. below initial (5 were below 400 lbs.) and the 10 from 57% r.h. averaging 40 lbs decrease at 12 months. Cases from 70°/80% averaged slightly below initial, those from 70°/57%, 40°/57%, and 0°/amb. averaged slightly above initial.

I.2. Moisture content of the fiberboard generally varied in direct proportion to storage humidity and inverse proportion to storage temperature. There was some indication that storage at 100°/80% may impair the moisture capacity of the fiberboard.

I.3. There were no significant changes in case flap seals, board delamination, or in extent of collapse as indicated by pressure wrinkles. The latter were roughly proportional to case full weights, which ranged from 33 to 80 lbs. No mold was observed inside the cases, although slight sweating at the 80% r.h. conditions was indicated by moisture and rust stains on the fiberboard. Sweating on the outside of the cases was also slight, with only three small areas of mold observed, one at 100°/80% and two at 70°/80% after 12 months.

I.4. Case markings remained generally in as legible condition as when received for storage.

II. Metal Cans. All cans, both the 2½-gallon and 5-gallon types, remained in acceptable condition after 12 or 18 months in storage.

II.1-3. Corrosion increased slightly on external surfaces of cans stored at 100° and 70°/80%. Lack of protective enamel, which is present on the 2½-gallon type, and presence of residual flux near side seams, apparently resulted in somewhat more extensive corrosion on the 5-gallon cans. Internal corrosion also increased slightly in cans at 100° and 70°F.

II.4. With the exception that rust spots had spread slightly under the borders of coating on the 5-gallon cans at 80% r.h., can coatings were in about the same condition as when received.

II.5. Of all cans examined to date, 16.3% of the 2½-gallon type (mostly biscuit CD4) and 3.1% of the 5-gallon type were leakers. Leakers increased slightly with storage, but no definite relationship with storage atmosphere or extent of corrosion was observed.

III.A. Shelter Rations. All samples of biscuits, crackers and wafers remained in acceptable condition after 12 or 18 months in storage, although effects of 100°, and in some items 70°, storage were definitely established.

III.A.1.a. Both seal breaks and torn packages averaged slightly higher in some items at 100° and at 0°F than at other conditions, but results were as yet inconclusive because of wide variations from can to can.

III.A.1.b. There were no consistent trends for product breakage as associated with storage time or temperature.

III.A.2.a. Sensory scores for appearance and color varied as much between duplicate samples as among storage conditions in many instances. Most products at 100° and some at 70°F were somewhat faded and very slightly glazed in appearance.

III.A.2.b. Hunter color values confirmed color changes at higher temperatures, all products exhibiting increases in L ("lightness") values and all except wafer CD10 showing decreases in "a" or red component and in a/b or red/yellow ratio.

III.A.3. The only definite trend in fracture strength of ration units was a decrease in variance between duplicate cans and among replicate units within cans. This indicated a tendency toward equalization of differences present after manufacture.

III.A.4.a. Headspace oxygen was definitely in inverse proportion to temperature of storage, and to a significant extent also to storage time. Levels were generally in inverse proportion to weight of product per unit volume of cans.

III.A.4.b. Moisture contents of rations varied considerably, but there was no definite association with storage time or temperature.

III.A.4.c. Peroxide values of fat extracted from rations followed the general pattern of increase to a maximum and subsequent decrease as headspace oxygen became reduced and oxidation reactions progressed toward stages of fat breakdown. These changes were definitely related to storage temperature. The stage of rapid peroxidation was apparently passed in wafers after 6-12 months, and in crackers CD1, CD3, CD5 and biscuits CD2, CD4 after 12-18 months at 100° and usually at 70°F. Free fatty acid (fat hydrolysis) values were associated with individual product stability, storage temperature, moisture level, and storage time, roughly in this order.

III.A.5.a. Sensory scores for aroma and flavor quality were generally associated with headspace oxygen and peroxide value patterns in relation to storage temperature and time. Scores exhibited a

slight tendency to reach a low at the period following maximum peroxidation and to then increase very slightly with further "aging" in sealed cans.

Texture scores showed the variability associated with lack of general agreement among judges as to how hard is "too hard", with some tendency to level out at 18 months. Scores averaged slightly higher in samples from 40° and 0° than those from 100°F after 12 or 18 months.

III.A.5.b. Hedonic ratings for aroma, flavor and palatability followed a general pattern of decrease in proportion to storage temperature and time, tending to average slightly higher for biscuits than for crackers and lower for wafers than for any other item.

III.A.5.c. Correlations of palatability ratings with objective measurements generally followed expected patterns, but variations among products and storage periods remained relatively high.

III.B. Carbohydrate Supplements. Initial examination of supplements CD11, CD12, CD13, with storage dated 27 March 1964, showed all product averages to be within specifications. Of five cans of item CD11, however, three exceeded a piece count of 120 per pound and two contained less than 40% of lemon-flavored candy in the mixture.

STUDY OF THE STORAGE STABILITY OF CONTAINERS AND FOOD
PROCURED FOR THE CIVIL DEFENSE SHELTER PROGRAM

During the second year of the study, 10 items of survival crackers, biscuits or wafers remained in continuous storage, and 3 lots of carbohydrate supplement (hard candy, lemon and cherry flavors) were examined as received and placed in storage (27 March 1964). Storage conditions for the period were as follows: (averages and standard deviations)

<u>Code</u>	<u>Temperature</u> °F	<u>Relative Humidity</u> percent
100/80	99.9, +1.9, -2.4	80.0, +4.4, -4.4
100/57	99.8, +1.7, -1.6	56.0, +3.1, -3.1
70/80	69.9, +0.7, -1.0	80.2, +2.2, -3.1
70/57	70.0, +2.7, -2.5	57.2, +4.4, -5.2
40/57	40.2, +2.4, -2.4	56.8, +2.6, -3.1
0/amb.	-2.2, +1.6, -0.7	ambient

Deviations in storage conditions were those in the air spaces surrounding the cases, resulting largely from the necessity of opening room doors to maintain equipment. Considerably smaller deviations may be assumed inside cases and cans.

Products examined during the second year were as follows:

<u>Code</u>	<u>Product</u>	<u>Storage Periods</u>
CD1	cracker	12 and 18 months
CD3	cracker	12 and 18 months
CD5	cracker	12 and 18 months
CD8	cracker	6 and 12 months
CD2	biscuit	12 and 18 months
CD4	biscuit	12 and 18 months
CD6	biscuit	12 months*
CD7	biscuit	12 months*
CD9	wafer, bulgur, white	6 and 12 months
CD10	wafer, bulgur, red	6 and 12 months
CD11	carbohydrate supplement	initial
CD12	carbohydrate supplement	initial
CD13	carbohydrate supplement	initial

*18 months examination too late for inclusion in current report.

Results of physical, chemical and sensory evaluations of cases, cans and products are given below. The basis for expression of results as means and standard deviations is indicated for each determination. Statements of significance of differences are based on analyses of variance, with reference to the 5% level of probability. Arrangement of data follows that set up in initial statements of work, Neg. Rec. AE-266-L and RDT&E-164-P.

I. Fiberboard (V3c) Cases

All cases of carbohydrate supplement, CD11-CD13, were in acceptable condition when received, in that at least the 54 cases stored from each lot were relatively undamaged from shipping, and the remaining 3 cases per lot were satisfactory for initial examination. Each case contained 2 cans. Manufacturer's data for the carbohydrate supplement, similar to that given for CD1-CD10 on pages 5 and 6 of Annual Report #I, are as follows:

<u>Code</u> CD	<u>Case</u> <u>Manufacturer*</u>	<u>Case Codes</u>	<u>Product</u> <u>Contract</u> CHI	<u>Product per can</u> lbs.
11	i	2	24018-63	35
12	j	1	24016-63	36
13	d	1 (not like CD5)	24023-63	34
	c	1 (not like CD3)	24013-63**	34

*Continuation of listing on p. 6, Annual Report #I.

**Only 11 cases of this, included in the 57 total cases; 1 case was examined (data not reported here) and 10 cases stored as reserve material.

Periodic examinations of items CD1-CD10 included 1 case (2 cans) per period for each product. Initial examinations for CD11-CD13 included 3 cases (6 cans, used for preliminary testing) of each product.

I.1. Bursting Strength, V3c fiberboard (Table 1).

The tendency for decrease in bursting strength at the 100°F and 70°/30% conditions, with slight increases at 70°/57% and the lower temperatures, was apparently established by the end of the first year in storage. The same trend is seen in data for cases from the first 5 items at 18 months, but changes during the third period were relatively slight. The 100°F temperature caused decreased strength at both relative humidities. While the influence of high humidity may be seen at 70° and in comparing the similar readings at 40°/57% and 0°/ambient (high) humidity, it apparently caused no significant decrease

TABLE 1

BURSTING STRENGTH OF V3c FIBERBOARD
(pounds per square inch)

Condition °F/% r.h.	Product Number										Mean
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10	
Initial ^a	485	451	434	507	401	477	491	535	498	463	474
<u>12 months:</u>											
100/80	365 ^b	392	413 ^b	420	363	425	443	501 ^b	359	370	405
100/57	374	444	430 ^b	473	391	444	465	474	405	435	434
70/80	394	477	471 ^b	469 ^b	381	459	481	536	425	449	454
70/57	448	443 ^b	491 ^b	500 ^b	399	475	522	545	479	516	482
40/57	462	495	472 ^b	511 ^b	393	480	509	586	495	509	491
0/amb	449 ^b	497	453	542	380	476	511	566	523	423	482
std. dev. (10 reps)	31	32	28	35	23	41	35	47	47	39	36
sign. dif. (5% level)	30	29	25	31	21	37	31	42	44	35	28
mean ^c (12 mo.)	415	458	455	486	384	460	489	535	448	450	458
<u>18 months:</u>						<u>6 months:</u> ^d					
100/80	405 ^b	421	377	478	388			528	349	339	424
100/57	345	445	391	459	366			517	389	420	453
70/80	418	431 ^b	405	489	399			529 ^b	424	429	463
70/57	477	486	461	490 ^b	436			535	478	488	498
40/57	496	536 ^b	486	513 ^b	410			619	474	476	507
0/amb	507 ^b	484 ^b	472 ^b	567	410			670	506	504	514
std. dev. (10 reps)	30	36	29	34	31			52	38	40	37
sign. dif. (5% level)	27	3	20	31	28			47	34	36	30
mean (18 mo.)	441	467	432	494	401	mean (6 mo)		566	437	443	476

^aInitial values for CD11, CD12, CD13 were 553, 365, 426, respectively.^bCase manufacturer's lot code different from that of initial case.^cSignificant difference (5% level) for product means at 12 months was 29 psig.^dCompletes Table 2, p.7, Annual Report #1.

in board strength.

Of the 25 sets of 6 cases each which have been removed from the storage rooms to date, none exhibited significant correlation of bursting strength with moisture content of the fiberboard. Comparing results at 6 months with those of later examinations, cases of items CD3, CD4, and CD5 shifted significantly toward a positive correlation (i.e., greater strength at higher moisture content), and all cases except those of CD2 and CD10 showed positive though non-significant correlations. Hence there appears little evidence that high moisture may be weakening the board as yet, although correlation of bursting test with water content in the 30 cases from high humidity rooms shifted from +.538 at 6 months to -.454 at 12 months.

I.2. Moisture Content, V3c fiberboard (Table 2).

Statements concerning comparisons of moisture from various examination periods are somewhat questionable, since actual content determined may be influenced by any fluctuation of storage atmosphere on the day of sampling. Such is at least suggested by the general decrease in moisture of cases removed from the 70°/57% room at 18 months. The decrease from the 100°/80% room at both 12 months and 18 months may have resulted from similar fluctuations, although chart records show no indication of drier conditions on either the second or third sampling dates. The alternate suggestion, that storage at 100°/80% may impair the moisture-holding capacity of the fiberboard, awaits further investigation.

I.3. General Condition of fiberboard cases.

The general physical state of the cases showed practically no evidence of change after 12 or 18 months of storage at any condition. There were no changes in seals, no signs of mold inside cases, and the only mold observed on the outside of cases was a small spot on CD7 from 100°/80% and on CD6 and CD7 from 70°/80% after 12 months. Of the total 150 cases removed from storage, the only sign of delamination was a slight fraying (averaging 0.2 ± 0.1 on a 9.0 scale) of flap corners on 9 cases.

There were a slight moisture stains, indicating mild sweating on the outside of some of the cases, at 12 and 18 months. At 12 months, the extent of such sweating on cases CD6-CD9 was rated 0.6 ± 0.3 (on 9.0 scale) from 100°/80% and 1.0 ± 0.4 from 70°/80%. Similar ratings from cases CD1-CD5 at 18 months were 0.5 ± 0.4 from 100°/80% and 1.0 ± 0.6 from 70°/80%.

Sweating inside the cases, with consequent depositing of slight amounts of moisture on cans, apparently began somewhat earlier than

TABLE 2
MOISTURE CONTENT OF V3c FIBERBOARD
(percent)

Condition °F/% r.h.	Product Number										Mean
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10	
Initial ^a	7.3	6.7	7.1	6.9	7.6	7.5	7.5	7.4	7.4	7.5	7.30
<u>12 months:</u>											
100/80	10.0	9.8	10.0	9.8	10.2	8.6	9.1	8.4	8.4	9.1	9.33
100/57	7.0	7.0	6.8	6.9	7.0	6.8	7.1	6.7	7.1	7.0	6.93
70/80	13.0	13.2	12.5	12.3	12.2	12.4	12.6	12.1	11.6	11.9	12.38
70/57	8.8	8.5	8.0	8.7	7.8	7.8	8.4	8.0	8.2	8.3	8.25
40/57	8.3	8.4	8.6	8.4	8.1	8.1	8.7	8.1	8.4	8.1	8.32
0/amb	12.1	12.0	12.3	12.5	12.4	12.8	12.3	12.2	12.5	12.1	12.33
std. dev. (2 reps)	.04	.07	.07	.09	.07	.03	.04	.03	.09	.07	.06
sign. dif. (5% level)	.09	.17	.18	.21	.16	.07	.11	.08	.21	.16	.34
mean ^b (12 mo.)	9.88	9.81	9.71	9.75	9.61	9.40	9.71	9.24	9.35	9.41	9.58
<u>18 months:</u>											
						<u>6 months:^c</u>					
100/80	8.9	8.7	9.0	8.9	9.1			10.7	10.5	10.7	10.64
100/57	7.1	7.0	7.2	7.3	7.2			7.2	7.4	7.5	7.40
70/80	12.2	12.2	12.6	12.4	12.4			12.6	10.9	11.8	12.10
70/57	7.3	7.5	7.5	7.3	7.0			7.5	7.8	8.1	8.22
40/57	8.3	8.5	8.9	8.3	8.4			8.3	8.4	8.1	8.66
0/amb	11.9	11.8	12.0	11.5	12.6			12.8	12.4	11.8	12.25
std. dev. (2 reps)	.04	.06	.07	.07	.05			.09	.07	.09	.07
sign. dif. (5% level)	.1	.15	.16	.17	.11			.22	.16	.21	.36
mean (18 mo.)	9.28	9.28	9.54	9.27	9.41		mean (6 mo)	9.84	9.55	9.66	9.87

^aInitial values for CD11, CD12, CD13 were 7.9, 7.6, 7.6, respectively.

^bSignificant difference (5% level) for product means at 12 months was 0.49%.

^cCompletes Table 3, p.9, Annual Report #1.

did moisture staining of the outside. In addition to the ice noted in CD5 and CD6 from 0°F at 6 months (Annual Report #I, p.8), evidences of moisture staining of inside surfaces of cases and outsides of cans were as follows (9.0 scale):

Condition °F/% r.h.	6 months (CD8-CD10)	12 months (CD1-CD10)	18 months (CD1-CD5)
100/80	0.3 ± .1	0.8 ± .6	0.4 ± .2
100/57	0.0	0.0	0.2 ± .1
70/80	0.2 ± .1	1.1 ± 1.0	0.7 ± .3
70/57	0.0	0.0	0.2 ± .1
40/57	0.0	0.0	0.2 ± .1
0/amb	0.0	0.0	0.3 ± .2

Collapse. As the cans fit snugly inside the cases, the only indication of collapse of cases without accompanying collapse of cans was the presence of pressure wrinkles in the corners and sides of the cases. The relative extent of this condition was generally no greater, and usually less than, in the initial cases, as the cases which suffered most shipping damage were used for initial examination. As expected, the extent of wrinkling was associated in some measure with the gross weight of the filled cases. With condition of cases graded on a 9-point scale (9 being no wrinkling or corner denting), relative extents of "collapse" were as follows:

Product	Case Weight	12 months	18 months	Condition	12 months	18 months
CD	gross lbs	(6 rooms)	(6 rooms)	°F/% r.h.	(CD1-CD5)	(CD1-CD5)
1	55	8.45	8.75	100/80	8.25	8.7
2	36	8.2	8.95	100/57	8.5	8.7
3	54	8.3	8.45	70/80	8.4	8.75
4	55	8.4	8.5	70/57	8.35	8.6
5	37	8.75	8.8	40/57	8.6	8.7
6	43	8.5		0/amb	8.45	8.7
7	35	8.7	6 months			
8	33	8.65	8.45		12 months	6 months
9	71	8.0	7.9		(CD6-CD10)	(CD8-CD10)
10	71	7.0	7.4			
		Initial		100/80	8.0	7.95
				100/57	7.8	6.95
				70/80	8.55	8.55
11	78	8.2		70/57	8.3	8.2
12	80	7.2		40/57	7.85	7.95
13	76	7.4		0/amb	8.5	7.85

I.4. Condition of case markings.

There was in general no significant fading or blurring of print on the cases within the first 18 months of storage. Graded on a 9-point

scale for legibility of printing, representative values as averages of all cases examined were as follows:

Product CD	Freedom From				Condition °F/% r.h.	Freedom From
	Fading		Blurring			
	initial	stored	initial	stored		Fading
					100/80	8.65
1	8.3	8.4	7.5	8.55	100/57	8.70
2	8.8	8.9	9.0	8.9	70/80	8.65
3	8.8	8.8	9.0	8.85	70/57	8.70
4	9.0	8.75	9.0	8.85	40/57	8.70
5	8.3	8.85	8.6	8.85	0/amb	8.75
6	9.0	8.85	7.9	8.85		
7	8.7	8.95	8.9	8.9		<u>Blurring</u>
8	8.7	8.85	8.7	8.75		
9	8.6	8.3	8.6	8.85	100/80	8.85
10	8.8	8.8	8.7	8.5	100/57	8.85
11	9.0	-	8.9	-	70/80	8.75
12	9.0	-	9.0	-	70/57	8.80
13	8.85	-	8.85	-	40/57	8.80
					0/amb	8.85

II. Hermetically Sealed Metal Cans

All cans, both the 2½-gallon size of CD1, CD3, CD4, and the 5-gallon type of the 10 other products, were in generally acceptable condition as received (CD11-CD13) or after storage for 6 months (CD8-CD10), 12 months (CD1-CD10) or 18 months (CD1-CD5). Several cans were found to have small leaks, but these were attributed to damaged seams or faulty closures and were apparently unrelated to extent of corrosion.

Data given below are derived from initial examination of 5 cans each of candies CD11-CD13, and from 2 cans each of the 10 bakery products removed from storage.

II.1-3. Severity, type and location of can corrosion (Table 3).

Extent of corrosion, and in most instances the severity of corrosion, increased slightly on external surfaces of most of the cans from 100°/80% and 70°/80% conditions. Increases were relatively greater on the 5-gal. cans than on the 2½-gal. type, apparently due to a combination of protective enamel on the smaller cans and residual flux near the side seams of the larger. No cans were really dangerously corroded at 18 months, although large rusted areas were beginning to form on the bottoms of some cans, again 5-gal. type,

TABLE 3
EXTERNAL AND INTERNAL CORROSION OF CANS AFTER STORAGE

Sample	Storage Condition, °F/% r.h.					Sign. dif. (5%)	Std. dif. (2 cans)	Mean
	100/80	100/57	70/80	70/57	40/57			
6 months:								
5-gal. external:								
CD8:								
severity ^a	1.2	0.6	0.4	0.6	0.6	0.5	NS	0.65
location	body near	near	near	body near	body near	body near		
and type	seams, S&P	seams, S&P	seams, S&P	seams, S&P	seams, S&P	seams, S&P		
CD9:								
severity	3.1	1.1	1.1	0.8	0.8	0.9	1.45	1.30
location	seams, body,	seams;	seams;	seams;	seams;	seams		
and type	bottom, P	bottom, P	bottom, P	bottom, P	bottom, S&P	S&P		
CD10:								
severity	2.9	0.9	0.6	0.6	0.8	0.5	.56	1.05
location	seams,	seams	seams,	body,	body,	body,		
and type	bottom, P	S&P	S&P	bottom, S&P	bottom, S&P	bottom, S&P		
Std. dif.	.95	.52	.22	.23	.36	.29	.47	-
(7 items) ^c								
Mean								
(7 items) ^c	2.10	0.71	1.00	0.69	0.69	0.56	.31	.33 ^d
5-gal. internal:								
CD8:								
severity	1.1	2.3	2.7	2.5	1.8	1.1	.53	1.92
location	body	body	body	body	body	body		
and type	S	S	S&P	S&P	S&P	S&P		
								(cont.)

(cont.)

Table 3 (con't)

Sample	Storage Condition, °F/% r.h.					Sign. dif. (5%)	Std. dif. (2 cans)	Mean
	100/80	70/57	70/80	70/57	40/57			
<u>6 months:</u>								
<u>5-gal. internal:</u>								
CD9: severity location and type	0.6 body S	0.9 body S	0.4 body S	0.6 body S	0.5 body S	NS	.35	0.57
CD10: severity location and type	0.5 body S	0.4 body S	0.3 body S	0.3 body S	0.6 body S	.15	.09	0.38
Std. dif. (7 items) ^c	.23	.29	.20	.22	.35	-	.27	-
Mean (7 items) ^c	0.69	0.74	0.79	0.81	0.73	NS	.24 ^d	0.73
<u>12 months:</u>								
<u>2 1/2-gal. external:</u>								
CD1: severity location and type	0.6 seams P	0.1 bottom seam, P	0.4 body, seam, P	0.1 seams S&P	0.1 body P	.32	.19	0.22
CD3: severity location and type	1.1 body, seams, P	0.8 body P	0.6 body, seams, bottom, P	0.3 seams P	0.4 body, seams, P	.42	.43	0.62

(con't.)

Table 3 (con't)

Sample	Storage Condition, °F/± r.h.					Sign. dif. (5%)	Std. dif. (2 cans)
	100/50	100/57	70/80	70/57	40/57		
<u>12 months:</u>							
<u>2-gal. external:</u>							
CD4:							
severity	1.1	4	0.4	0.2	0.2	.45	.26
location	body	seams, P	body, P	body, P	body, P		
and type	seams, P		seams, P	seams, P	seams, P		
Std. dif., 2 cans	.20	.12	.26	.20	.37	-	-
(3 items)							
Mean						.16	.26 ^d
(3 items)	0.93	0.43	0.47	0.20	0.23		0.43
<u>5-gal. external:</u>							
CD2:							
severity	1.1	0.6	1.4	0.6	0.5	.48	.28
location	bottom	bottom	seams	seams	seams		
and type	seams, P	seams, P	P	P	P		
CD5:							
severity	2.8	1.1	1.7	0.7	0.4	.71	.40
location	near	body, near	body, near	body	body		
and type	seams, P	seams, P	seams, P	P	P		
CD6:							
severity	1.4	0.8	1.2	0.5	0.3	.41	.24
location	bottom, body,	body, P	bottom, body,	near	seams		
and type	seams, P	seams, P	seams, P	seams, P	P		
CD7:							
severity	3.3	0.2	1.0	0.5	0.2	.51	.29
location	near	body	near	body	near		
and type	seams, P	P	seams, P	P	seams, P		

(con't)

Table 3 (cont.)

Sample	Storage Condition, °F/% r.h.					dif. (5%)	dif. (2 ca)	Mean
	100/80	100/57	70/80	70/57	40/57			
<u>12 months:</u>								
<u>5-gal. external:</u>								
CD8:								
severity	1.4	0.3	0.7	0.5	0.2	.35	.20	0.55
location	bottom,	near	bottom,	bottom,	near			
and type	seams, P	seams, S&P	seams, P	seams, P	seams, P			
CD9:								
severity	1.7	0.6	1.3	0.7	0.6	.59	.34	0.87
location	bottom, body,	body	body	body	body			
and type	seams, P	P	P	P	P			
CD10:								
severity	1.8	0.6	0.9	0.5	0.5	.35	.20	0.75
location	bottom, body,	bottom, body,	bottom, body,	body, near	bottom, body			
and type	seams, P	seams, P	seams, P	seams, P	seams, P			
Std. dif., 2 cans	.38	.26	.37	.27	.23	-	.29	-
Mean								
(7 items)	1.57	0.60	1.17	0.57	0.39	.18	.23 ^d	0.77
<u>2 1/2-gal. internal:</u>								
CD1:								
severity	0.5	0.7	0.7	0.4	0.5	.20	.20	0.57
location	body, S	body, S	body	body	body			
and type	seams, P	seams, P	S&P	S&P	S&P			
CD3:								
severity	0.4	0.5	0.7	0.9	0.7	.19	.19	0.62
location	body	body	body, S	body, S	body, S			
and type	S	S&P	seams, P	seams, P	seams, P			

(cont.)

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Table 3 (cont)

Sample	Storage Condition, °F/% r.h.					dif. (5%)	dif. (2 cans)	Mean
	100/80	100/57	70/80	70/57	40/57			
<u>12 months:</u>								
<u>2½-gal. internal:</u>								
CD4:								
severity	0.8	0.6	0.6	0.5	0.7	.29	.22	0.58
location	body		body	body	body			
and type	S&P		S&P	S&P	S&P			
Std. dif., 2 cans								
(3 items)	.26	.26	.17	.17	.20	-	.20	-
Mean								
(3 items)	0.60	0.60	0.67	0.60	0.63	.17	NS	0.59
<u>5-gal. internal:</u>								
CD2:								
severity	0.3	0.3	0.4	0.3	0.5	.15	.15	0.38
location	body	body	body	body	body			
and type	S	S	S	S	S&P			
CD5:								
severity	0.9	1.0	1.2	0.6	1.2	.28	.26	0.97
location	body	body, S	body	body	body			
and type	S&P	seams, P	S&P	S	S&P			
CD6:								
severity	0.5	0.4	0.1	0.1	0.0	NS	.40	0.25
location	body	body	body	body				
and type	S	S	S	S				
CD7:								
severity	0.7	0.4	0.7	0.6	0.5	.18	.19	0.60
location	body	body	body	body	body			
and type	S	S	S	S	S			

(cont)

Table 3 (con't)

Table 3 (con't)

Sample	Storage Condition, °F/% r.h.					Sign. dif. (5%)	Std. dif. (2 cans)	Mean
	10/80	10/57	70/80	70/57	40/57			
<u>12 months:</u>								
<u>5-gal. internal:</u>								
CD8: severity location and type	1.0 body S&P	1.3 body S&P	0.8 body S&P	1.1 body S&P	1.1 body S&P	NS	.37	1.03
CD9: severity location and type	1.1 body S&P	0.6 body S	0.9 body S&P	0.9 body S&P	0.8 body S&P	.28	.26	0.78
CD10: severity location and type	0.5 body S	0.5 body S	0.6 body S	0.6 body S	0.6 body S	NS	.17	0.57
Std. dif., 2 cans (7 items)	.33	.35	.20	.26	.26	-	.27	-
Mean (7 items)	0.71	0.64	0.67	0.60	0.67	NS	.18 ^d	0.65
<u>18 months:</u>								
<u>21-gal. external:</u>								
CD1: severity location and type	1.3 bottom, body, seams, P	0.0	0.75 body seams, P	0.2 near seams, P	0.2 seams P	.16	.16	0.41
CD3: severity location and type	1.1 seams P	0.55 seams P	0.55 seams P	0.35 seams P	0.3 seams P	.31	.18	0.51

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(con't)

(con't)

Table 3 (con't)

Sample	Storage Condition, °F/% r.h.					Sign. dif. (5%)	Std. dif. (2 cans)	Mean
	100/80	100/57	70/80	70/57	40/57			
<u>18 months:</u>								
<u>24-gal. external:</u>								
CD4:								
severity	1.5	1.1	1:25	0.5	0.9	.58	.58	1.03
location	bottom, body	"	bottom, body,	body S	body			
and type	seams, S&P	"	seams, S&P	seams P	S&P			
Std. dif., 2 cans	.60	.13	.35	.06	.37	-	.36	-
(3 items)								
Mean						.18	.29 ^d	0.84
(3 items)	1.30	0.62	0.85	0.35	0.47			
<u>24-gal. internal:</u>								
CD1:								
severity	0.7	0.8	0.65	0.5	0.7	NS	.28	0.66
location	body	body	body	body	body			
and type	S&P	S&P	S	S	S&P			
CD3:								
severity	0.7	0.95	0.35	0.6	0.6	.19	.11	0.64
location	body, S	body,	body	body, S	body			
and type	seams, P	seams, S	S	seams, P	S			
CD4:								
severity	0.9	1.3	0.4	0.55	0.5	.39	.37	0.68
location	body	body	body	body	body			
and type	S&P	S&P	S	S	S&P			
Std. dif., 2 cans	.39	.27	.09	.13	.37	-	.28	-
(3 items)								
Mean						.17	NS ^d	0.66
(3 items)	0.17	1.02	0.47	0.55	0.60			

(con't)

Table 3 (cont.)

Sample	Storage Condition, °F/% r.h.					Sign. dif. (5%)	Std. dif. (2 cans)	Mean
	100/80	100/57	70/80	70/57	40/57			
<u>18 months:</u>								
<u>5-gal. external:</u>								
CD2: severity location and type	1.8 bottom, body, seams, P	0.7 body, seams, P	1.2 bottom, body, seams, P	0.75 body, seams, P	0.4 body P	.46	.27	0.85
CD5: severity location and type	2.5 bottom, seams, P	0.9 seams P	1.55 seams P	0.9 seams P	0.45 seams P	1.04	.98	1.10
<u>5-gal. internal:</u>								
CD2: severity location and type	0.3 body S	0.6 body S&P	0.3 body S	0.2 body S	0.4 body S	.28	.21	0.36
CD5: severity location and type	0.7 body S	0.95 body S&P	0.75 body S	0.7 body S	0.8 body S	NS	.56	0.78

^aExpressed as 9.0-point grade, with grade of 0.0 = no corrosion.

^bSurface = S, or pitted = P.

^cIncludes the 5-gal. cans from Table 5, Annual Report #1.

^dSignificant difference (5% level) for product means.

from the 80% r.h. conditions.

Interior corrosion also increased to slight extents in cans from 100° and 70°F, but no damage to either cans or products was observed or indicated except in a few instances of leaking seams.

Initial corrosion ratings for 5 cans of each of the three lots of Carbohydrate Supplement were as follows:

	<u>External</u>		<u>Internal</u>	
	<u>severity</u> (9.0-point)	<u>location and type</u>	<u>severity</u> (9.0-point)	<u>location and type</u>
CD11	0.48 ± .31	body and near seams, P	0.54 ± .17	where candy rested on metal, S & slight P
CD12	0.56 ± .09	same, P	0.72 ± .11	same, S & slight P
CD13	0.36 ± .19	same, P	0.50 ± .10	same, S & slight P

II.4. Defects in exterior can coating.

With the exception that rust spots had apparently spread slightly under the coating near seams on a few 5-gal. cans from 80% r.h. rooms, can coatings were in about the same condition after 6, 12, or 18 months as when received. Average ratings (9-point scale) for uniformity of coatings were as follows:

Product	<u>12 months</u>		<u>18 months</u>		<u>Condition</u> <u>*F/% r.h.</u>	<u>2 1/2-gal. cans</u>		<u>5-gal. cans</u>	
	<u>std.^a</u>	<u>rating</u>	<u>std.^a</u>	<u>rating</u>		<u>std.^a</u>	<u>rating</u>	<u>std.^a</u>	<u>rating</u>
CD					12 months				
1	.15	8.70	.17	8.62	100/80	.37	8.21	.34	8.40
3	.52	8.48	.22	8.28	100/57	.17	8.41	.27	8.33
4	.29	8.32	.53	7.83	70/80	.29	8.23	.14	8.60
mean		8.50		8.27	70/57	.26	8.40	.42	8.57
					40/57	.26	8.50	.11	8.63
2	.20	8.40	.25	8.22	0/amb	.53	8.54	.33	8.47
5	.47	8.00	.59	8.20	Sign.dif.	0.16	-	0.14	-
6	.15	8.68							
7	.36	8.38	<u>6 months</u>						
8	.15	8.50	.15	8.55					
9	.32	8.28	.24	8.20					
10	.20	8.38	.15	8.33					
mean		8.39	.29	8.35 ^b					
Sign.dif.				.26 ^b					
(5')		0.21	-	0.26 ^b					

^aPooled estimate of differences between the 2 cans of each sample from storage.

^bIncludes the products in 5-gal. cans from Annual Report #I, p.16.

II.5. Leaking Cans (Table 4).

In the inspection of results of leak testing during the second year of the studies, it became apparent that the classification as leaker or non-leaker was uncertain in some instances of cans which emitted an apparently steady stream of bubbles during the test, but at a very slow rate. These cans were re-evaluated on the basis of whether any other sign of leaking, such as increased headspace oxygen at higher temperatures or increased moisture at higher humidity, was also present. Cans lacking such confirming evidence were then reclassified as "questionable leaker". All cans tested to date, including those listed on pp 16-17 of Annual Report #I, are included in Table 4.

Summarizing the data, there were 16.3% leakers and 1.6% questionable leakers in the 2 $\frac{1}{2}$ -gal. cans (12.2% of each of these were in CD4), 3.1% leakers and 1.8% questionable leakers in the 5-gal. cans. Percentages of leakers were somewhat high after storage (none of the 5-gal. cans leaked initially), but there was little or no definite relationship with time or condition of storage.

III.A. The Shelter Rations

All package seal breaks and holes, major and minor, were reported through 6 months of storage (Annual Report #I, Table 7), or are included here for items CD8-CD10. Beginning with 12 months, only breaks or holes large enough to allow loss of ration units in handling will be reported, as minor breaks are both quite numerous and relatively unimportant in the sealed cans.

Separation of units of the crackers (CD1, CD3, CD5, CD8) and biscuits (CD2, CD4, CD6, CD7) in the layers as packed, crumbling of edges of the single-unit layers of wafers (CD9, CD10), and unit breakage of each of these products will continue to be reported as in Annual Report #I, Table 8, but major crushing or shattering of units will also be included in 12-months and subsequent data.

III.A.1.a. Breakage of package seals and wrapping materials (Table 5).

Data in Table 5 show a small but significant percentage of broken seals in packages of CD10 and of torn packages in CD6 and CD7 at 12 months. Both seal breaks and torn packages averaged higher at 100° and 0°F than at 70° or 40°. Seal breaks were also relatively higher in CD1, CD4 and CD5 at 18 months, with fairly low percentages of packages torn sufficiently to allow escape of ration units. There is still not enough data to indicate possible time effects on the state of the packages, as can and case variations are apparently present to a significant extent.

TABLE 4
NUMBERS OF LEAKING CANS

Sample ^a	Product									
	CD1	CD3	CD4	CD2	CD5	CD6	CD7	CD8	CD9	CD10
Initial ^b	0	1 _{ts}	1 _{pt} &2 _t *	0	0	0	0	0	0	0
<u>100/80:</u>										
6 mo.	0	0	2 _t *	0	0	1 _t	0	0	0	0
12 mo.	0	1 _t *	1 _{ts} *	0	0	0	0	0	0	0
18 mo.	0	1 _{ts} *	1 _{ts} &1 _s *	0	0					
<u>100/57:</u>										
6 mo.	0	0	1 _{ts} &1 _t *	0	1 _t	0	0	0	0	0
12 mo.	0	0	1 _t	0	0	1 _t &1 _{ts} *	0	0	0	0
18 mo.	0	0	0	0	0					
<u>70/80:</u>										
6 mo.	0	1 _t	2 _{ts}	0	1 _t	0	0	0	0	0
12 mo.	1 _s &1 _t *	0	1 _t &1 _t *	0	0	0	0	0	0	0
18 mo.	0	1 _t	0	0	0					
<u>70/57:</u>										
6 mo.	0	0	2 _{ts} *	0	0	0	0	0	0	0
12 mo.	0	0	1 _{ts}	0	1 _t	0	0	0	0	0
18 mo.	0	0	2 _t *	0	1 _{tc}					
<u>40/57:</u>										
6 mo.	0	0	2 _t	0	1 _t	0	0	0	0	0
12 mo.	0	0	1 _t &1 _t *	0	0	0	0	0	0	0
18 mo.	1 _{sd}	0	1 _t &1 _t *	0	0					
<u>0/amb:</u>										
6 mo.	0		1 _t	0	1 _t *	0	0	0	0	0
12 mo.	0	0	1 _t	0	0	0	1 _t *	0	0	0
18 mo.	0	0	1 _{tc} &1 _t *	1 _t *	0					

^aAll initial samples were 5 cans each except CD6 (3 cans) and CD7 (4 cans).

^bAll samples from storage were 2 cans each.

^cInitial numbers of leakers for CD11, CD12, CD13 were 1_t&1_t*, 0, 1_{fd}&1_t*, respectively.

*Questionable leaker.

t = top seam. s = side seam. f = factory (bottom) seam. p = pinhole.

d = dented. c = cleavage at seam (tight plates).

TABLE 5

PACKAGE SEAL BREAKS, HOLES, AND TOTAL PACKAGES BROKEN
(percent of total packages per sample)

Sample	Store	Conditions	°F/% r.h.	Standard difference 2 cans	Significant difference 5% level	Mean
	100/80	100/70/80	70/57 40/57 0/amb			
6 MONTHS:^a						
<u>Cracker:</u>						
CD8:						
unsealed	65	83	69	75	58	65
torn	92	100	71	98	92	92
total	98	100	94	100	96	97
<u>Wafers:</u>						
CD9:						
unsealed	1.6	2.4	2.0	1.6	2.4	2.05
torn	.4	2.0	2.8	2.0	2.0	1.85
total	2.0	4.4	4.8	3.6	4.4	3.90
CD10:						
unsealed	6.8	.0	1.2	2.0	1.6	2.32
torn	.0	1.2	.0	1.2	1.6	.79
total	6.8	1.2	1.2	3.2	3.2	3.04
12 MONTHS:^b						
<u>Biscuits:</u>						
CD2:						
total	.0	.0	.0	.0	.0	.00
CD4:						
total	.0	.0	.0	.0	.0	.00
CD6:						
torn	5.4	10.7	3.6	.0	1.8	12.5
CD7:						
torn	8.3	2.1	2.1	6.3	2.1	7.8

(con't)

Table 5 (cont.)

Table 5 (cont.)								
Sample	Storage Conditions, °F/% r.h.					Standard difference 2 cans	Significant difference 5% level	Mean
	100/80	100/57	70/80	70/57	40/57			
12 MONTHS: ^b								
<u>Crackers:</u>								
CD1:								
unsealed	3.3	.0	.0	.0	.0	2.7	NS	.56
torn	3.3	.0	.0	.0	.0	.0	.1	1.12
total	6.7	.0	.0	.0	.0	.0	.1	1.12
CD3:								
torn	.0	.0	6.7	.0	.0	6.1	NS	1.67
CD5:								
total	.0	.0	.0	.0	.0	-	-	.00
CD8:								
total	.0	.0	.0	.0	.0	-	-	.00
<u>Wafers:</u>								
CD9:								
unsealed	.0	.0	.0	.0	.4	.4	.5	.20
torn	.0	.8	.0	.4	.0	.8	1.2	.40
total	.0	.8	.0	.4	.4	.9	1.2	.60
CD10:								
unsealed	.4	.0	.0	.4	1.2	2.1	NS	.73
torn	.0	.0	.0	.0	.0	.3	NS	.07
total	.4	.0	.0	.4	1.2	2.5	NS	.80
<u>All Items:</u>								
Std. dif., 2 cans:								
unsealed	2.2	-	-	.3	.4	-	.67 ^c	1.09
torn	5.8	7.0	5.0	1.4	1.8	-	2.54 ^c	4.64
total	5.5	7.0	5.0	1.4	1.8	-	3.39 ^c	4.6 ^c
Mean:								
unsealed	.37	.00	.00	.04	.16	-	.30 ^d	.15
torn	1.71	1.36	1.23	.66	.39	-	NS ^d	1.22
total	2.08	1.36	1.23	.70	.55	-	1.52 ^d	1.37
(cont.)								

(cont.)

Table 5 (con't)

Sample	Storage Conditions, °F/% r.h.					Standard difference 2 cans	Significant difference 5% level	Mean
	100/80	70/80	70/57	40/57	0/amb			
18 MONTHS: ^b								
<u>Biscuits:</u>								
CD2:								
total	.0	.0	.0	.0	.0	-	-	.00
CD4:								
unsealed	6.7	.0	13.4	6.7	3.3	20.6	NS	8.34
torn	3.3	.0	3.3	.0	.0	3.9	NS	1.12
total	10.0	.0	16.7	6.7	3.3	19.5	NS	9.46
<u>Crackers:</u>								
CD1:								
unsealed	6.7	10.0	13.4	13.3	16.7	13.9	NS	11.12
torn	.0	10.0	3.3	.0	.0	3.9	6.7	2.23
total	6.7	16.7	16.7	13.3	16.7	14.2	NS	12.79
CD3:								
unsealed	3.3	.0	.0	.0	.0	2.8	NS	.56
torn	.0	.0	.0	3.3	.0	2.8	NS	.56
total	3.3	.0	.0	3.3	.0	3.9	NS	1.12
CD5:								
unsealed	4.2	2.1	.0	12.4	10.4	11.1	NS	4.86
torn	.0	2.1	4.2	4.2	.0	5.1	NS	1.73
total	4.2	4.2	4.2	14.6	10.4	13.0	NS	6.25

^aMajor and minor breaks, as in Annual Report #I.

^bMajor breaks only.

^cSignificant difference for product means.

^dSignificant difference for storage condition means.

III.A.1.b. Breakage of products (Table 6).

Data in Table 6 indicate no consistent trend for changes in score-line separations, broken units, or combined unit breakage with increased time to 18 months. Variations were rather heterogeneous, and frequently there were greater differences between the 2 cans per sample (standard 2-can differences for 6 X 2 cans are given for each product) than between products, storage conditions, or storage periods. Products tended to remain fairly consistent; i.e., CD2 and CD6 remained low in breakage, CD3 and CD5 fairly high, etc. The exception was wafers, which exhibited extreme can and case differences in extent of chipping of the edges. This defect was not considered very important, resulting only in a moderate amount of crumbs to be disposed of when packages were opened for use.

III.A.2.a. Sensory quality scores, appearance and color, (Table 7).

There were no significant changes in appearance of rations examined after storage up to 18 months, with the exception of a slightly glazed appearance and slight fading of color in many of the samples from 100°F. Hence scores for appearance were influenced more by color changes than by any other factor, and the two were averaged for inclusion as a single factor in the current report.

Data in Table 7 illustrate the fact that variations among cases (one case per storage condition) and cans within cases were often greater than trends which could be attributed to storage.

Comments by judges scoring appearance and color were about the same as those given on p.25, Annual Report #I.

III.A.2.b. Hunter color values (Table 8).

Color data reported for items CD1-CD7 at 6 months (Annual Report #I, p.26) were L, a, and b values, on the assumption that browning, as indicated by changes in a/b and b, would take place in storage. After 18 months, however, there was little indication that browning was a major factor in color changes; the major change was fading at higher temperatures. Hence color values reported here are L, a, and a/b, as these show changes associated with fading.

The effects of temperature and time of storage are seen in Table 8. All items except wafer CD10 faded to some extent at 100° and 70°F, as indicated by increased L values and decreased a and a/b (L = lightness value, +a = redness, +b = yellowness). CD10 exhibited a slight general increase in L, but no significant changes in a or a/b. In this instance, as with items CD1, CD5, CD6 and CD9, some fading would probably have resulted in higher color scores, as these items were considered to be fairly dark or unevenly browned in the initial state.

TABLE 6

UNITS SEPARATED IN LAYERS, UNITS BROKEN, AND TOTAL BREAKAGE
(as percent of "score lines" and total units per sample)

Sample	Storage Conditions, °F/% r.h.						Standard difference 2 cans	Significant difference 5% level	Mean
	100/80	57	70/80	70/57	40/57	0/amb			
6 MONTHS:									
<u>Cracker:</u>									
CD8:									
separated	7.1	10.7	7.8	12.8	11.1	18.3	9.1	NS	11.30
broken	14.4	21.5	10.2	22.9	12.7	22.2	6.6	9.0	17.32
total	17.9	26.8	14.1	29.4	18.3	31.4	10.5	14.3	22.98
<u>Maifrs:a</u>									
CD9:									
chipped	.00	.66	.00	.00	.00	.00	.54	NS	.11
broken	.07	.40	.20	.26	.13	.46	.33	NS	.25
total	.07	1.06	.20	.26	.13	.46	.57	.82	.36
CD10:									
chipped	.66	36.71	.00	.00	1.65	15.15	12.07	20.88	9.03
broken	.53	.46	.93	.66	.26	1.39	.82	NS	.70
total	1.19	37.17	.93	.66	1.91	16.54	12.66	21.90	9.73
12 MONTHS:									
<u>Biscuits:</u>									
CD2:									
separated	5.8	3.5	8.9	5.4	6.5	6.0	5.2	NS	6.00
broken	2.7	.5	1.7	1.6	1.9	1.8	1.6	NS	1.67
total	8.5	4.0	10.6	7.0	8.4	7.8	5.3	NS	7.69
CD4:									
separated	8.7	4.3	3.8	4.0	4.5	4.7	4.4	NS	4.99
broken	10.3	12.8	11.7	9.5	10.2	13.0	4.1	NS	11.27
crushed	.0	.0	1.9	.4	.0	.0	1.6	NS	.39
total	14.7	17.9	15.5	11.9	12.5	15.4	4.2	NS	14.16

(con't)

2210.8 #II

Table 6 (con't)

Sample	Storage Conditions, °F/% r.h.					Standard difference 2 cans	Significant difference 5% level	Mean
	100/80	100/57	70/80	70/57	40/57			
<u>12 MONTHS:</u>								
<u>Biscuits:</u>								
<u>CD6:</u>								
separated	1.3	6.3	1.0	1.0	1.3	2.1	2.1	2.00
broken	1	7.5	1.5	1.0	2.3	4.1	1.8	3.03
crushed	.0	.6	.2	.0	.1	.0	.4	.15
total	2.2	14.4	2.7	2.0	3.7	6.2	2.5	5.18
<u>CD7:</u>								
separated	11.4	3.0	3.9	9.3	3.9	6.5	4.5	6.30
broken	8.4	3.2	3.8	10.0	4.2	5.0	2.5	5.79
crushed	.2	.3	.2	.5	.2	1.0	NS	.38
total	20.0	6.5	7.9	19.8	8.3	12.5	8.2	12.47
<u>Crackers:</u>								
<u>CD1:</u>								
separated	27.2	12.4	21.9	13.9	21.5	9.1	NS	17.66
broken	10.5	6.9	9.3	22.5	7.0	5.5	4.4	10.28
crushed	1.9	.2	1.0	2.3	.2	.0	NS	.93
total	25.9	13.2	21.2	31.8	17.9	10.0	11.5	20.03
<u>CD3:</u>								
separated	15.2	13.1	22.9	16.7	16.8	15.3	NS	16.67
broken	6.3	14.1	18.1	11.1	6.5	20.3	NS	12.73
crushed	.0	1.7	.2	.4	.2	4.5	2.2	1.17
total	21.5	28.9	41.2	28.2	23.5	40.1	12.5	30.57
<u>CD5:</u>								
separated	22.6	20.0	14.1	9.1	28.6	8.0	15.4	17.08
broken	21.5	18.2	18.6	8.4	26.4	7.9	6.6	16.95
crushed	8.0	1.5	1.8	.3	2.6	.4	7.6	2.43
total	52.2	39.7	34.5	17.8	57.7	16.3	23.5	36.36
(con't)								

(con't)

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2210.8

#II

Table 6 (cont.)

Sample	Storage Conditions, °F/% r.h.					difference 2 cans	difference 5% level	Mean
	100/80	70/57	70/80	70/57	40/57			
12 MONTHS:								
Crackers:								
CD8:								
separated	8.0		7.4	5.4	7.2	3.7	NS	7.49
broken	11.8	20.7	9.6	22.2	19.7	4.1	7.1	17.21
crushed	.0	1.8	.4	2.1	1.3	1.8	NS	1.00
total	15.8	26.8	13.7	27.0	24.6	4.8	8.3	21.98
CD1-CD8:								
Std. dif., 2 cans: ^b								
separated	5.9	7.0	9.0	7.3	10.7		6.78 ^c	7.73
broken	2.7	3.1	8.9	4.1	3.5		4.48 ^c	5.03
crushed	4.3	1.5	1.5	1.5	1.5		1.35 ^c	2.17
total	7.0	7.1	5.4	5.6	11.4		8.29 ^c	7.18
Mean:							3.04 ^d	
separated	12.40	8.90	10.49	8.10	11.29	7.51	NS	
broken	9.19	10.49	9.29	10.79	9.78	9.60	NS	
crushed	1.26	.76	.71	.75	.58	.80	NS	
total	20.10	18.55	18.41	18.19	19.58	16.53		
Wafers: ^a								
CD9:								
chipped	55.80	32.15	27.40	50.10	36.45	35.60	26.21	39.58
broken	.00	.07	.13	.07	.33	.20	.19	.13
total ^e	55.80	32.15	27.45	50.10	36.50	35.70	26.23	39.62
CD10:								
chipped	51.30	58.30	27.40	54.80	61.75	74.85	16.70	54.73
broken	.13	.46	.13	.33	.13	1.46	NS	.44
total ^e	51.30	58.30	27.40	54.95	61.75	74.85	16.70	54.76
18 MONTHS:								
Biscuits:								
CD2:								
separated	4.3	1.1	2.8	4.4	2.6	3.5	4.7	3.65
broken	1.2	1.5	1.4	2.1	.6	.8	1.4	1.64
total	5.5	2.7	4.2	6.5	3.2	3.5	4.7	5.29
(con't)								

(cont.)

Table 6 (con't)

Sample	Storage Conditions, °F/% r.h.					Standard difference 2 cans	Significant difference 5% level	Mean
	100/80	100/57	70/80	70/57	40/57			
<u>18 CONTINIS:</u>								
<u>Biscuits:</u>								
CD4:								
separated	6.3	7.0	5.6	4.9	6.7	2.9	NS	5.57
broken	14.5	9.1	16.9	14.4	12.1	11.8	4.9	13.12
crushed	.9	.0	.9	1.8	.0	.0	NS	.60
total	18	12.6	20.6	18.7	15.5	13.3	4.1	16.53
<u>Crackers:</u>								
CD1:								
separated	11.9	5.1	12.2	12.6	40.3	21.5	18.2	17.25
broken	18.2	7.9	16.2	18.0	14.1	11.4	9.1	14.31
crushed	.0	.0	5.8	1.8	.0	.0	NS	1.27
total	24.2	10.5	28.0	26.0	34.2	22.1	12.9	24.18
CD3:								
separated	12.8	16.3	13.8	17.6	12.6	9.9	NS	13.83
broken	10.6	7.0	13.6	12.8	6.4	6.5	4.9	9.48
crushed	.0	.0	.6	.9	.0	.0	.7	.25
total	23.4	23.3	28.0	31.3	19.0	16.4	9.1	23.56
CD5:								
separated	19.9	16.4	14.5	22.2	9.4	21.2	11.8	17.28
broken	16.6	21.5	20.0	20.4	21.6	20.9	NS	20.17
crushed	.5	1.6	1.0	.3	.7	.0	NS	.69
total	37.0	39.5	35.5	42.9	31.7	42.1	NS	38.14

^aWafers are not joined by indented lines in layers, hence chipped edges instead of broken

^bScore lines were noted.

^cSignificant differences for products in storage conditions may be estimated as standard difference X 1.63.

^dSignificant difference for product means.

^eSignificant difference for storage condition means.

^fTotal wafers broken, whether chipped or separated into pieces; i.e., most broken wafers were also chipped.

TABLE 7

SENSORY SCORES, APPEARANCE AND COLOR
(scale from 10 = excellent to 1 = poor)

Condition °F/% r.h.	Product Number ^a										Mean ^b
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10	
Initial	6.5	8.2	7.0	7.85	7.5	6.8	8.3	7.0	7.7	6.5	7.34
<u>12 Months:</u>											
100/80	6.7	7.35	7.0	6.95	7.35	7.7	6.7	6.3	6.15	6.25	6.85
100/57	6.75	7.25	6.95	7.25	6.7	7.1	6.8	6.6	6.55	6.2	6.82
70/80	7.2	7.1	7.15	6.8	6.95	6.8	7.25	7.2	6.55	6.25	6.93
70/57	6.25	7.5	7.3	7.55	7.35	6.45	7.25	6.55	5.95	6.2	6.84
40/57	6.65	7.45	7.2	6.6	6.7	6.4	7.15	7.4	7.25	6.2	6.90
0/amb	6.85	7.5	7.1	7.35	6.9	6.55	7.6	7.4	7.35	6.15	7.08
Std.dif. (2 cans)	.61	.39	.26	.57	.33	.62	.25	.45	.40	.20	.43
Sign.dif. (5% level)	.94	NS	NS	.88	.51	.96	.44	.78	.70	NS	.16
Mean ^c (12 mo.)	6.73	7.36	7.12	7.08	6.99	6.83	7.13	6.91	6.63	6.21	6.90
Std.dev. (judges)	1.29	.96	1.09	1.24	1.01	1.22	1.57	1.15	1.49	1.81	1.31
<u>18 Months:</u>						<u>6 Months:</u>					
100/80	7.05	7.95	7.0	6.85	7.2			6.8	7.0	6.65	7.49
100/57	6.85	7.8	7.4	7.15	7.8			6.9	7.3	6.35	7.34
70/80	7.15	7.6	7.5	7.45	7.5			6.65	6.35	6.75	7.28
70/57	7.2	7.95	7.15	7.6	7.6			6.8	6.6	6.85	7.33
40/57	6.55	7.8	7.45	7.15	7.8			6.85	7.1	6.95	7.20
0/amb	7.65	7.65	7.4	7.55	8.05			6.8	7.35	7.35	7.26
Std.dif. (2 cans)	.82	.23	.30	.72	.47			.37	.43	.40	.55
Sign.dif. (5% level)	NS	NS	.47	NS	.73			NS	.67	.62	.21
Mean (18 mo.)	7.08	7.79	7.32	7.29	7.66		mean (6 mo.)	6.80	6.95	6.82	7.32
Std.dev. (judges)	1.25	.73	1.11	.77	.78		1	1.27	1.18	1.24	1.36

^a Items 1, 3, 5, 8 are crackers; 2, 4, 6, 7 are biscuits; 9, 10 are bulgur wafers.

^b Means for 6 months also include all 10 items.

^c Significant difference for product means at 12 months is 0.48.

TABLE 8
HUNTER COLOR VALUES OF SHELTER RATIONS

Sample	Storage Conditions, °F/% r.h.					Std.dif. 2 cans	Sign.dif. 5%	Mean
	100/80	70/50	70/80	70/57	40/57			
<u>6 MONTHS:</u>								
<u>Cracker:</u>								
CD8:								
L	71.2	68.9	70.2	68.0	67.5	66.4	1.4	68.70
a	1.6	2.5	2.1	3.1	3.2	3.3	.4	2.64
a/b	.074	.111	.096	.138	.143	.150	.017	.118
								b = 22.31 ± .13
<u>Wafers:</u>								
CD9:								
L	61.2	60.4	63.3	62.2	61.5	60.2	.8	61.45
a	4.1	4.7	3.5	4.0	3.9	4.4	.6	4.09
a/b	.189	.214	.162	.184	.179	.207	.022	.189
								b = 21.66 ± .26
<u>CD10:</u>								
L	54.1	55.2	55.0	54.8	54.6	54.1	.7	54.63
a	5.3	4.8	5.0	5.1	5.0	4.9	.5	5.01
a/b	.268	.253	.250	.255	.261	.262	.024	.258
								b = 19.42 ± .45
<u>12 MONTHS:</u>								
<u>Biscuits:</u>								
CD2:								
L	70.6	70.4	69.3	71.1	67.9	68.2	.6	69.55
a	1.0	1.2	2.3	1.7	2.1	1.8	.6	1.65
a/b	.045	.056	.109	.082	.098	.084	.028	.079
								b = 20.90 ± .30
								(cont.)

(cont.)

Table 8 (con't)

Table 8 (con't)									
Sample	Storage Conditions, °F/% r.h.						Std.dif. 2 cans	Sign.dif. 5%	Mean
	100/80	70/57	70/80	70/57	40/57	0/amb			
12 MONTHS:									
Biscuits:									
CD4:									
L	74.3	75.6	74.7	74.1	74.6	73.5	1.1	1.6	74.47
a	.8	.3	.7	.8	.4	.9	.5	NS	.66
a/b	.040	.715	.035	.041	.021	.044	.025	NS	.033
									b = 20.32 ± .29
CD6:									
L	64.6	63.6	61.0	60.7	59.6	58.4	.4	.6	61.31
a	3.4	3.9	4.6	4.9	5.5	6.1	.8	1.4	4.72
a/b	.135	.160	.194	.202	.226	.252	.029	.051	.194
									b = 24.28 ± .34
CD7:									
L	72.7	74.1	73.7	72.6	72.8	69.6	.8	1.4	72.59
a	1.2	.8	1.2	2.0	1.7	3.5	1.3	2.0	1.72
a/b	.054	.038	.053	.089	.076	.155	.057	.088	.078
									b = 22.09 ± .29
Crackers:									
CD1:									
L	63.0	62.4	64.2	62.1	60.7	60.3	2.2	3.3	62.14
a	4.3	4.6	4.3	5.2	5.3	5.5	.7	1.1	4.84
a/b	.169	.185	.167	.206	.209	.217	.033	NS	.192
									b = 25.21 ± .17
CD3:									
L	1.7	71.5	70.7	70.7	70.5	69.0	.5	.9	70.66
a	.3	.4	.8	.9	1.0	1.7	.7	1.1	.83
a/b	.011	.018	.035	.042	.043	.074	.031	.048	.037
									b = 22.08 ± .24

(cont.)

Table 8 (con't)

Sample	Storage Conditions, °F/% r.h.						Std.dif. 2 cans	Sign.dif. 5%	Mean
	100/80	100/57	70/80	70/57	40/57	0/amb			
12 MONTHS:									
Crackers:									
CD5:									
L	60.8	60.4	58.3	58.5	58.4		1.4	2.1	59.52
a	5.9	6.2	6.6	6.8	7.0		.6	.8	6.39
a/b	.230	.227	.238	.265	.273		.024	.037	.250
									b = 25.55 ± .34
CD8:									
L	71.5	70.6	72.5	71.3	71.1		.8	1.3	71.31
a	1.5	2.4	1.6	2.1	2.2		.4	.6	1.98
a/b	.067	.105	.071	.093	.096		.015	.028	.088
									b = 22.45 ± .08
Wafers:									
CD9:									
L	62.1	62.0	62.0	63.2	61.3	61.4	.7	NS	61.99
a	3.4	3.9	3.8	3.2	4.0	4.1	.7	NS	3.72
a/b	.159	.178	.176	.149	.184	.192	.031	NS	.173
									b = 21.51 ± .09
CD10:									
L	56.0	55.3	56.6	56.4	55.3	56.1	.7	1.0	55.91
a	4.6	4.8	4.3	4.5	4.9	4.6	.6	NS	4.61
a/b	.240	.254	.222	.241	.259	.245	.030	NS	.243
									b = 18.96 ± .29
Std.dif., 2 cans:									
L	.83	.73	.75	1.37	1.66	.99		.85 ^b	1.12
a	.51	.66	.75	.78	.80	.62		.45 ^b	.69
a/b	.024	.030	.032	.036	.037	.030		.020 ^b	.332
								b = .27 ^b	b = .4 ^c
									(cont.)

(con't.)

Table 8 (con't)

Sample	Storage Conditions, °F/% r.h.						Std.dif. 2 cans	Sign.dif. 5%	Mean
	100/80	100/57	70/80	70/57	40/57	0/amb			
<u>12 MONTHS:</u>									
Mean:	66.72	66.02	66.51	66.03	65.19	64.60			64.13 ^d
L	2.63	2.81	2.96	3.18	3.37	3.72		.70 ^c	3.41 ^d
a	.117	.126	.132	.144	.151	.166		.016 ^c	.155 ^d
a/b	22.49	22.31	22.34	22.15	22.28	22.42		.22 ^c	21.98 ^d
b									
<u>18 MONTHS:</u>									
Biscuits:									
CD2:	82.6	72.5	72.5	71.4	71.0	71.1	.8	1.3	71.84
L	1.6	1.7	1.7	2.2	2.3	2.4	.3	.4	1.98
a	.078	.084	.085	.111	.118	.120	.010	.016	.099
a/b									b = 19.63 ± .27
CD4:	77.4	76.8	76.1	77.8	75.3	75.4	.7	1.1	76.44
L	.3	.8	.9	.0	1.3	1.4	.5	.8	.75
a	.015	.038	.044	.000	.067	.069	.024	.041	.039
a/b									b = 19.38 ± .33
Crackers:									
CD1:	65.3	64.2	64.0	63.7	62.5	63.1	.8	NS	63.80
L	4.5	4.9	4.9	5.1	5.6	5.6	.7	1.1	5.07
a	.130	.197	.194	.203	.221	.219	.031	NS	.202
a/b									b = 25.06 ± .26

(con't)

Table 8 (cont.)

Sample	Storage Conditions, °F/% r.h.					Std.dif. 2 cans	Sign.dif. 5%	Mean
	100/80	100/57	70/80	70/57	40/57			
<u>18 MONTHS:</u>								
<u>Crackers:</u>								
CD3:								
L	74.0	77	72.2	71.9	71.1	70.7	.9	72.26
a	.8		1.4	1.5	1.8	2.1	.3	1.33
a/b	.036	.026	.063	.067	.034	.094	.012	.062
								b = 21.43 ± .32
CD5:								
L	63.3	64.7	60.6	60.6	59.5	60.1	.7	61.14
a	5.7	5.5	7.2	7.0	7.6	7.3	.5	6.71
a/b	.222	.211	.279	.280	.297	.282	.017	.262
								b = 25.64 ± .30

a Significant differences for products in storage conditions may be estimated as standard differences

x 1.58.

b Significant difference for product means.

c Significant difference for storage condition means.

d Initial mean for the 10 items.

III.A.3. Fracture strength of ration items (Table 9).

Correction of Errors: Table 10, p.29, Annual Report #I, should be corrected to read as follows:

Condition	CD1	CD3	CD5	CD2	CD4	CD6	CD7	Std.dev. ^b	Mean ^d
<u>Initial^a:</u>	1410	1060	1550	1530	1145	1570	1295	98	1310
Std.dev. ^b (cans)	64	54	51	58	41	35	50		
Std.dev. ^c (30 reps)	222	232	212	144	196	214	115		

Data in Table 9 indicate no definite trends for changes in fracture strength, although there is some suggestion of greater values at lower temperatures and possibly a slight decrease in values after the first 6 months in storage. Variations between replicate cans and among units within cans showed a definite decrease at each sampling period, indicating that differences present after manufacture are tending toward equalization.

III.A.4.a. Headspace oxygen in cans (Table 10).

Absorption of oxygen by products in the cans continued to be generally proportional to storage temperature, storage time, and, to some extent, to weight of product per 5-gal. can space. (Product weights were equivalent to ca 12.75 lbs per 5-gal. can for CD2 and CD8; 14.0-14.6 lbs for CD1, CD3-5, and CD7; 18.5 lbs for CD6; 32.3-33.0 lbs for CD9 and CD10). Absorption at 40°/57% and 0°/amb. was relatively slight except in wafers, and much of the decrease probably occurred during the week of temperature equalization after cans were removed from storage.

It is still somewhat early to attempt an evaluation of the relationship between changes in oxygen and those in other product characteristics. Such evaluation, and comparisons among sealed and leaking cans as to effect on other characteristics, will be made at a later date.

III.A.4.b. Moisture content of rations in cans (Table 11).

Moisture data in Table 11 indicate considerable variation from can to can, and as there was no consistent trend for storage conditions, apparently also from case to case. Several leaking cans which had differences in oxygen content were about the same as corresponding non-leakers in moisture content; other leakers which were different in moisture are shown. Product differences remained fairly consistent,

TABLE 9

FRACTURE STRENGTH OF RATION ITEMS
(grams to break)

Condition	Product Number ^a										Mean ^b
^a F/r.h.	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10	
Initial	1411	1532	1062	1147	1549	1571	1296	1139	2159	1283	1415
											std.dif. = 151
12 Months:											rep.dev. = 391
100/80	1606	1612	1061	1009	1384	1864	1145	1033	1507	1553	1397
100/57	1549	1663	1104	989	1332	1787	1220	998	2192	1619	1445
70/80	1386	1682	1055	926	1131	1860	1203	1237	2033	1544	1406
70/57	1445	1696	1016	981	1177	1971	1118	1085	2016	1522	1403
40/57	1533	1682	1127	950	1347	1941	1191	1187	2327	1531	1482
0/amb	1584	1684	1157	1102	1177	1831	1305	1251	2131	1300	1452
Std.dif. (2 cans)	189	89	107	73	137	50	50	109	97	133	111
Sign.dif. (5% level)	NS	NS	NS	126	237	85	85	188	168	232	55
Mean ^c (12 mo.)	1517	1670	1087	993	1258	1876	1197	1132	2034	1545	1431
Std.dev. (20 reps)	214	156	221	174	179	153	134	199	203	150	181
18 Months:											
											6 Months:
100/80	1429	1625	1006	1044	1434			1018	2223	1509	1454
100/57	1440	1583	961	1057	1167			1032	1999	1240	1385
70/80	1501	1604	1036	1005	1233			1081	1609	1529	1422
70/57	1388	1632	1034	1083	1346			1238	2023	1443	1470
40/57	1499	1616	1089	1040	1559			1245	2084	1452	1490
0/amb	1441	1674	976	1048	1229			1125	2072	1343	1478
Std.dif. (2 cans)	55	8	53	43	191			55	371	128	152
Sign.dif. (5% level)	95	NS	92	74	330			94	NS	221	76
Mean ^c (18 mo.)	1449	1622	1017	1046	1328	mean (6 mo.)	1123	2001	1419		1450
Std.dev. (20 reps)	194	146	156	154	150			187	239	221	202

^aItems 1, 3, 5, & are crackers; 2, 4, 6, 7 are biscuits; 9, 10 are bulgur wafers.

^bMeans for 6 months also include all 10 items.

^cSignificant difference for product means at 12 months was 105.

TABLE 1C
HEADSPACE OXYGEN IN CANS OF SHELTER RATIONS
(percent oxygen by volume)

Condition °F/% r.h.	Product Number ^a										Std.dif. 2 cans ^b	Mean b
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
Initial: sealed leakers	19.3	20.1	20.1 20.3	20.3 20.5	19.7	17.8	20.4	20.4	16.6	17.0	.45	19.16
12 Months:												
100/80: sealed leaker	11.3	15.2	11.8 13.5	16.5	10.4	11.7	17.7	14.9	7.1	7.2	1.87	12.38
100/57: sealed leakers	9.1	15.6	12.8	17.4 20.6	10.6	14.2 20.8	17.6	13.7	6.0	7.6	1.13	12.46
70/80: sealed leakers	14.7 15.9	18.8	18.0	19.3 19.5	15.3	16.4	19.4	13.1	8.2	12.5	1.10	16.07
70/57: sealed leakers	14.8	18.9	17.6	19.5 20.2	16.3 18.7	16.2	19.6	18.3	8.6	10.8	1.02	16.06
100/57: sealed leaker	17.1	19.7	19.1	20.3 20.6	19.0	16.5	20.2	19.8	15.7	13.3	1.04	18.27
0/amb: sealed leakers	17.7	20.2	20.0	20.3 20.6	19.5	17.5	20.5 20.7	19.9	16.4	15.7	.30	18.77

(cont)

Table 10 (con't)

Condition: %F/% r.n.	Product Number ^a										Std.dif. 2 cans ^b	Mean p
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
<u>12 Months:</u>												
Std.dif., 2 cans: sealed .32		.53	1.32	.81	.73	2.31	.15	.89	1.58	1.23		1.17
Sign.dif., 5%: sealed .6		1.0	2.3	1.4	1.3	4.0	.3	1.6	2.8	2.2	1.18 ^d	.92
Mean, 12 mo.: sealed	14.12	18.07	16.55	18.88	15.18	15.44	19.22	17.47	10.67	11.20		15.68
<u>18 Months:</u>												
<u>6 Months:</u>												
10/1/80: sealed	9.0	12.7	7.5	18.2	6.0			16.8	9.1	8.8	.84	14.46
leakers			9.7	20.3								
100/57: sealed	9.5	14.5	8.7	17.5	4.4			15.6	7.4	5.6	.95	13.61
70/80: sealed	13.2	18.5	17.7	19.9	15.3			18.8	11.2	9.8	1.00	16.67
leaker			19.2									
70/57: sealed	14.3	18.3	16.6	20.4	16.0			18.9	11.8	10.9	.46	16.71
leakers				20.7	20.8							
40/57: sealed	16.5	19.9	19.0	20.8	18.2			19.7	15.9	13.8	1.02	18.30
leakers	20.9			20.8								
0/amb: sealed	17.8	20.2	20.1	20.8	18.8			19.9	15.9	15.1	.45	18.58
leakers		20.3		20.9								
(con't)												

(con't)

Table 10 (cont)

Condition °F/g r.h.	Product Number ^a										Std.dif. 2 cans ^b	Mean ^c
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
18 Months:												
Std.dif., 2 cans:												
sealed	2.84	1.47	2.17	1.14	2.00			.31	.87	1.20		.77
Sign.dif., 5%:												
sealed	5.0	2.6	3.8	2.0	3.5			.6	1.5	2.1	.78 ^d	.61
Mean, 18 mo.:												
sealed	13.18	17.32	14.91	19.58	13.09		Mean (6 mo.)	18.29	11.88	10.64		16.38

6 Months:

^aItems 1, 3, 5, 8 are crackers; 2, 4, 6, 7 are biscuits; 9, 10 are bulgur wafers.
^bValues for 6 months also include all 10 items.
^cQuestionable leakers having no apparent increase in headspace O₂ are included with sealed cans.
^dSignificant difference for product means. Significant differences among 10 products in storage conditions may be estimated as standard difference X 1.58.

TABLE 11
MOISTURE CONTENT OF SHELTER RATONS
(percent)

Condition °F/% r.h.	Product Number ^a										Std. dif. 2 cans ^b	Mean b
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
Initial leaker ^d	1.85	2.12	2.12	1.69	1.42	2.50	1.96	3.60	4.01	4.03	.33	2.51
			2.49									
12 Months:												
100/80	2.71	2.63	2.71	2.18	2.06	2.61	2.18	2.10	4.27	3.43	.30	2.69
100/57	2.23	2.69	2.70	2.54	1.95	3.00	2.84	2.77	3.77	3.40	.29	2.79
70/80	3.41	2.81	2.95	2.41	2.51	2.92	3.00	3.70	3.74	3.75	.28	3.12
leaker	3.86											
70/57	3.27	3.43	2.87	2.40	1.90	3.12	1.84	2.91	4.01	3.47	.34	2.92
leaker				2.15								
40/57	2.63	2.58	3.41	3.09	2.06	3.24	2.60	3.13	3.80	3.50	.43	3.00
leaker				2.63								
O/amb	2.46	2.60	2.57	2.35	2.14	2.28	1.70	3.36	3.74	3.40	.27	2.66
Std. dif. ^e	.67	.17	.38	.23	.27	.21	.16	.40	.21	.09	.32	.24 ^f
(2 cans)												
Mean	2.79	2.79	2.87	2.50	2.10	2.86	2.36	3.00	3.89	3.49	.28	2.87
(12 mo.)												
18 Months:												
100/80	2.29	2.00	2.17	1.56	1.25			3.18	3.56	3.50	.24	2.73
100/57	1.71	1.94	2.29	1.57	1.85			2.61	3.86	3.03	.14	2.68

(con't)

Table 11 (cont)

Condition or % r.h.	Product Number ^a										Std.dif. 2 cans ^{b,c}	Mean b
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
<u>18 Months:</u>												
70/80 leaker	2.35	2.17	2.19	1.60	1.31			2.53	3.35	3.71	.24	2.82
70/57 leaker	2.35	2.12	2.09	2.27	1.09			2.63	3.62	3.88	.35	2.75
40/57 leakers	2.49	2.22	2.28	1.81	1.38			2.48	3.77	3.28	.23	2.68
0/amb	1.64			2.09								
Std.dif. ^e (2 cans)	2.05	2.23	2.09	1.77	1.79			2.40	3.62	3.28	.49	2.61
Mean (18 mo.)	.72	.20	.26	.17	.40			.28	.09	.08	.30	.23 ^f
	2.18	2.11	2.19	1.76	1.45			2.64	3.71	3.52	.28 ^g	2.71

^aItems 1, 3, 5, 8 are crackers; 2, 4, 6, 7 are biscuits; 9, 10 are bulgur wafers.

^bValues for 6 months also include 10 items.

^cSignificant differences for products in storage conditions may be estimated as standard difference X 1.58.

^dLeakers with apparently normal moisture are included with values for sealed cans.

^eSignificant differences for storage conditions in each product may be estimated as standard difference X 1.73.

^fSignificant difference for storage condition means.

^gSignificant difference for product means.

but an apparent trend for general increases or decreases at various examination periods is still unexplained. Examination procedures will be checked for possible unrealized variations in methodology.

III.A.4.c. Rancidity values (peroxides and free fatty acids in extracted fats, Tables 12 and 13).

As shown by data in Tables 10 and 12, the pattern of oxygen absorption and subsequent peroxidation has progressed in a normal or expected manner for items CD1-CD8. This pattern is initial absorption of oxygen, followed by peroxidation at a faster rate than that of succeeding oxidation reactions which lead to formation of carbonyl-type compounds. As the latter reactions then become established, and oxygen is depleted in sealed cans, peroxide levels decrease and sensory evidence (staleness followed by rancidity) of the presence of oxidation products of fat breakdown begins to appear. The terminal stages, and decrease in peroxide levels, may occur more rapidly in leaking cans, as these have more available oxygen to speed up the process.

The oxidation pattern in the wafers, CD9 and CD10, was apparently well underway when the cans were received for storage. This was indicated by lower headspace oxygen values and some staleness or slight rancidity on initial examination, plus the fact that the peroxide values have remained fairly low in 100°F storage but followed the normal pattern at 70° and later at 47°.

The first five items, CD1-CD5, had apparently passed the stage of rapid peroxidation after 18 months in storage; the initiation of the oxidation by some "shock" such as baking or other processing, and the eventual retrogression of the cycle in sealed cans, are also part of the usual pattern. Unsealed products normally undergo a similar cycle, with the exception that they usually continue to rancidify at a greater rate than when sealed.

The free fatty acid (fat hydrolysis) values given in Table 13 also indicate an approximately normal pattern in that degree of hydrolysis varies with the stability of the fat, tended to increase at higher temperatures and moisture levels, tended to remain fairly low in actively oxidizing fats, and residual free acids tended to decrease to some extent during the more active stages of the oxidation cycle. Conversely, fats with a high degree of hydrolysis usually exhibit low peroxide values as did biscuit CD4, with sensory rancidity of the type often described as "soapy" or "acid". A moderate tendency in this direction was also exhibited by wafer CD9.

There was no known reason for the apparent periodic dip in free acid levels of products CD1-CD5 at 12 months; analytical techniques are being carefully observed as a possible cause.

TABLE 12
PEROXIDE VALUES OF FATS FROM SHELTER RATIONS
(milli-equivalents per kilogram)

Condition °F/°r.h.	Product Number ^a										Std.dif. 2 cans ^{b,c}	Mean b
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
Initial	1.1	1.1	.8	.4	.6	.9	.8	.8	2.0	1.4	.5	.98
12 Months:												
100/80 leaker ^d	19.3	4.6	33.7	6.2	18.0	11.2	7.9	26.6	3.5	2.8	3.7	13.34
100/57 leaker	13.6	4.0	53.0	1.9	16.2	9.7	3.8	23.2	3.6	3.0	3.0	13.18
70/80 leaker	3.2	1.0	7.1	1.1	.9	1.9	3.5	1.4	17.2	5.1	.5	4.22
70/57 leaker	1.0	.8	6.2	1.1	1.2	1.6	1.2	.9	16.4	4.6	1.2	3.46
40/57 O/amb	.6	.9	.8	.7	.7	.9	1.1	.9	6.6	3.7	.6	1.68
Std.dif. ^e (2 cans)	.3	.8	.6	.4	.6	.9	1.2	1.0	4.9	3.4	.3	1.41
Mean (12 mo.)	1.7	.7	1.1	.3	3.4	4.1	.8	2.0	1.7	.7	2.1	4.52 ^f
	6.27	2.03	16.88	1.89	6.27	4.34	3.09	9.00	8.67	3.77	6.65 ^g	6.22
18 Months:												
100/80	2.8	1.3	2.9	1.5	2.5			1.4	2.8	1.3	.8	3.70
100/57	1.2	2.0	3.0	1.7	2.1			3.4	2.4	1.6	1.0	3.97

(cont.)

Table 12 (con't)

Condition °F/° R. L.	Product Number ^a										Std.dif. 2 cans ^{b,c}	Mean b
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
<u>6 Months:</u>												
70/80	.4	1	1.5	.4	.5			.7	8.3	1.4	.5	1.85
70/57	.4	.0	2.0	.0	.0			.8	6.0	1.5	.2	1.60
leaker					.4							
40/57	.0	.0	.4	.0	.0			.7	3.9	.7	.3	1.05
0/amb	.0	.0	.0	.0	.0			.6	1.7	.8	.2	.78
Std.dif. ^e (2 cans)	.3	.3	.5	.4	.3			.4	.7	.3	.6	1.25 ^f
Mean (18 mo.)	.79	.55	1.63	.59	.85	Mean (6 mo.):	1.28	4.20	1.21	1.83 ^g		2.16

6 Months:

^aItems 1, 3, 5, 8 are crackers; 2, 4, 6, 7 are biscuits; 9, 10 are bulgur wafers.^bValues for 6 months also include 10 items.^cSignificant differences for products in storage conditions may be estimated as standard difference X 1.58.^dLeakers with apparently normal moisture are included with values for sealed cans.^eSignificant differences for storage conditions in each product may be estimated as standard difference X 1.73.^fSignificant difference for storage condition means.^gSignificant difference for product means.

TABLE 13
FREE FATTY ACID VALUES OF FATS FROM SHELTER RATIIONS
(percent as oleic acid)

Condition F/R.h.	Product Number ^a										Std. dif. 2 cans bc	Mean b
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
Initial	.168	.191	.229	.615	.194	.135	.278	.358	.338	.320	.031	.280
12 Months:												
100/80	.139	.174	.307	.614	.144	.192	.314	.359	.543	.391	.049	.318
100/57	.154	.165	.302	.618	.118	.181	.419	.364	.466	.390	.039	.318
70/80	.112	.134	.228	.591	.133	.169	.336	.342	.419	.390	.026	.285
70/57	.113	.160	.256	.584	.137	.163	.289	.334	.380	.319	.025	.274
leaker ^d				.606								
40/57	.110	.151	.236	.582	.121	.166	.298	.331	.369	.335	.026	.270
0/amb	.103	.153	.207	.572	.131	.143	.266	.330	.339	.334	.024	.258
leaker							.323					
Std. dif. ^e (2 cans)	.016	.012	.018	.013	.015	.028	.041	.031	.055	.057	.033	.020 ^f
Mean (12 mo.)	.122	.156	.256	.593	.131	.169	.320	.343	.420	.360	.025 ^g	.287
18 Months:												
100/80	.190	.215	.367	.660	.188			.339	.478	.432	.015	.295
100/57	.189	.202	.356	.653	.207			.346	.482	.377	.013	.302
70/80	.142	.166	.249	.564	.170			.311	.432	.391	.026	.287
70/57	.142	.159	.236	.624	.170			.296	.427	.409	.026	.274

(cont)

Table 12 (cont.)

Condition of F/R. ¹	Product Numbers ^a										Std.dif. 2 cans ^b	Mean b
	UD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
<u>18 Months:</u>												
40/57	.131	.	.24	.588	.146			.287	.413	.375	.012	.273
O/amb	.146	.	.225	.596	.145			.288	.377	.361	.034	.254
Std.dif. ^e												
(2 cans)	.013	.027	.015	.010	.012			.036	.043	.022	.025	.015 ^f
Mean						Mean						
(18 mo.)	.157	.176	.280	.614	.171	(6 mo.):	.311	.435	.391	.0198		.283

^aItems 1, 3, 5, 8 are crackers; 2, 4, 6, 7 are biscuits; 9, 10 are bulgur wafers.

^bValues for 6 months also include 10 items.

^cSignificant differences for products in storage conditions may be estimated as standard difference X 1.58.

^dLeakers with apparently normal moisture are included with values for sealed cans.

^eSignificant differences for storage conditions in each product may be estimated as standard difference X 1.73.

^fSignificant difference for storage condition means.

^gSignificant difference for product means.

III.A.5.a. Sensory Quality; aroma, flavor, texture (Table 14).

The general pattern of sensory quality scores, as shown in Table 14, was similar to that of headspace oxygen and peroxide values of the fat, as shown above. In proportion to time and temperature, scores for aroma and flavor decreased through 12 months of storage, but scores for items CD1-CD5 at 18 months showed a tendency to increase to levels between the 6-months and 12-months ranges. This phenomenon is not infrequently observed in products going through the closed-system oxidation cycle. Breakdown products of oxidizing fat tend to accumulate on or near the product surfaces during the active stage, but subsequently volatilize or equalize throughout the product as the cycle "levels off", hence are no longer so far ahead of product flavor in initial taste impression.

The apparent improvement of flavor or "aging" of products in storage, which also involves protein changes in high-nitrogen foods, was observed repeatedly in the preceding study of storage of military rations (Dept. of Army Surveys of Progress... Series IV.2; also Ga. Exp. Station Tech. Bul. N.S. 25. 1962).

Texture scores exhibited less range than those on aroma and flavor and were slightly less variable in duplicate cans, but taste panel judges did not agree as closely on texture as on aroma in many instances. The main point of disagreement was on how hard is "too hard," as most of the survival rations are of the very, crisp type. Some difficulty in scoring storage quality as separate from hedonic impression is also seen in texture and, particularly, in flavor deviations among the judges.

Levels of scores among the 10 products, as seen in Table 14, generally varied in about the same relationship as that shown on initial examination, and comments were approximately the same as on initial and 6-months judgements. There was an apparent tendency for product differences to level out somewhat at 18 months.

III.A.5.b. Hedonic Ratings; aroma, flavor, palatability (Table 15).

The general pattern of hedonic rating means, despite the relatively high judge variance, was rather consistent from initial through the examinations made at 18 months. Ratings decreased approximately in proportion to storage temperature and time, tended to average slightly higher for biscuits (particularly CD2) than for crackers, and remained generally lower for bulgur wafers than for either biscuits or crackers.

Scores on flavor tended to decrease more than those on aroma (which showed no average decrease) at 6 months, but aroma ratings averaged lower at 12 and 18 months, with staleness given as the usual reason. Palatability ratings averaged somewhat higher than either aroma or flavor ratings after the first period. Product and

TABLE 14
SENSORY SCORES FOR AROMA, FLAVOR, AND TEXTURE OF SHELTER RATIONS
(Scale from 10 = excellent to 1 = poor; means for five judges of two cans)

Condition of F/2 r.h.	Product Number ^a										Std. dif. 2 cans bc	Mean b
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
Initial:												
aroma	7.0	7.0	7.2	8.0	7.2	6.4	6.4	6.4	6.0	6.4		6.87
flavor	6.0	8.4	7.0	7.5	6.3	6.4	7.8	6.4	6.2	5.4		6.74
texture	6.5	7.8	7.3	8.2	6.8	6.4	8.2	7.4	6.2	5.8		7.06
12 Months:												
100/80:												
aroma	5.6	6.3	5.2	5.7	5.0	5.9	5.6	5.2	4.7	5.4	.9	5.46
flavor	6.2	6.2	5.3	5.7	5.0	6.4	5.8	5.4	5.4	5.3	.5	5.67
texture	6.2	7.1	6.4	7.0	5.9	6.6	6.8	6.4	6.3	5.3	.6	6.40
100/57:												
aroma	5.5	5.8	5.1	5.3	4.7	5.6	5.2	5.9	5.2	5.1	.8	5.34
flavor	5.9	6.1	5.0	5.9	4.8	5.7	5.6	5.8	5.7	5.2	.8	5.57
texture	6.2	7.1	6.2	7.0	5.6	6.4	7.0	6.4	6.2	5.4	.7	6.35
70/80:												
aroma	5.7	7.3	6.3	6.2	5.0	6.5	6.5	6.4	5.5	4.7	.6	6.01
flavor	5.9	6.3	6.0	6.3	5.0	6.3	6.7	6.4	6.5	5.3	.4	6.07
texture	6.4	6.9	6.5	7.1	5.6	6.1	7.0	6.8	6.4	5.3	.5	6.41
70/57:												
aroma	5.5	7.6	6.5	6.9	5.1	6.2	6.7	6.5	5.1	5.3	.5	6.14
flavor	5.8	6.5	6.1	7.0	5.3	6.2	7.1	7.0	6.0	5.3	.4	6.26
texture	4.2	6.8	6.3	7.2	6.1	6.1	7.1	7.1	6.3	5.2	.5	6.44

(cont.)

Table 14 (cont.)

Condition °F/g r.h.	Product Numbers ^a										Std. dif. 2 cans bc	Mean b
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
<u>12 Months:</u>												
40/57:												
aroma	6.6	7.1	6.7	6.9	6.1	6.3	6.9	6.8	6.4	5.7	.8	6.55
flavor	6.6	7.0	6.8	7.3	5.7	6.0	7.2	6.8	6.8	5.5	.9	6.57
texture	6.6	7.2	7.0	7.4	5.7	6.0	7.5	7.3	6.5	5.3	.7	6.65
O/amb:												
aroma	6.7	7.4	7.0	7.3	5.7	6.4	7.1	7.3	6.7	5.5	.8	6.71
flavor	6.9	7.3	6.8	7.4	5.8	6.3	7.5	7.0	7.0	5.7	.6	6.77
texture	6.6	7.5	6.7	7.2	6.1	6.0	7.2	7.2	6.3	5.1	.5	6.59
Std. dif., 2 cans: d												
aroma	1.3	.4	.6	.3	.6	.9	.6	.8	.9	.6	.71	.37 ^e
flavor	.8	.8	.4	.6	.5	.5	.6	.3	1.0	.6	.60	.39 ^e
texture	.4	.5	.4	.6	.4	1.1	.4	.4	.9	.3	.55	.21 ^e
Mean, 12 mo.:												
aroma	6.93	6.92	6.13	6.38	5.27	6.15	6.33	6.35	5.60	5.28	.48 ^f	6.03
flavor	6.22	6.57	6.00	6.60	5.27	6.15	6.65	6.40	6.23	5.43	.51 ^f	6.15
texture	6.37	7.10	6.52	7.15	5.83	6.20	7.10	6.87	6.33	5.27	.46 ^f	6.47
<u>18 Months:</u>												
100/80:												
aroma	6.2	6.0	5.2	6.2	5.6			6.7	5.9	5.5	.4	6.57
flavor	6.2	5.6	6.0	5.7	5.7			6.0	6.1	6.0	.6	6.26
texture	5.4	7.2	6.3	6.9	6.7			6.1	6.3	6.2	.7	7.03
100/57:												
aroma	5.9	6.0	5.5	6.7	5.5			6.5	6.1	5.9	.5	6.57
flavor	6.2	5.7	6.3	6.1	5.4			5.5	5.9	5.8	.6	6.17
texture	6.7	7.0	7.0	7.2	6.8			6.2	6.7	5.8	.4	6.72

(con't)

(cont.)

Table 14 (cont.)

Condition °F/% r.h.	Product Number ^a						CD8	CD9	CD10	Std. dif. 2 cans bc	Mean b	
	CD1	CD2	CD3	CD4	CD5	CD6						
18 Months:												
6 Months:												
70/80:												
aroma	6.8	6.9	6.6	6.9	6.4		6.4	6.1	6.5	.6	6.75	
flavor	6.6	6.8	7	6.5	6.6		5.4	6.1	6.3	.6	6.35	
texture	6.8	7.5	.1	7.3	6.9		6.0	6.1	6.5	.5	6.76	
70/57:												
aroma	6.8	7.0	6.8	7.1	6.8		6.4	6.4	6.6	.5	6.69	
flavor	6.7	7.4	6.8	6.6	6.8		6.0	6.1	6.3	.7	6.41	
texture	7.0	7.7	6.8	7.2	6.9		6.7	6.4	6.5	.5	6.94	
40/57:												
aroma	6.7	7.7	7.1	7.0	7.2		6.3	6.5	7.3	.7	6.90	
flavor	6.9	7.5	7.2	6.8	7.1		6.0	6.6	7.2	.8	6.52	
texture	6.9	7.4	7.1	7.3	7.1		6.3	7.1	7.0	.6	6.96	
0/amb:												
aroma	7.0	7.4	7.2	7.2	7.6		6.6	6.6	7.5	.6	6.92	
flavor	6.9	7.4	7.3	7.0	7.6		6.1	6.8	7.2	.7	6.53	
texture	7.1	7.2	7.3	7.3	7.1		6.7	7.1	7.1	.6	6.98	
Std. dif., 2 cans:												
aroma	.8	.6	.7	.5	.3		.4	.4	.5	.50	.27 ^e	
flavor	.4	.7	.3	.4	.3		.6	.7	.6	.63	.35 ^e	
texture	.4	.5	.5	.6	.3		.6	.7	.5	.54	.22 ^e	
Mean, 18 mo.:	6.56	6.83	6.40	6.85	6.52	Mean, 6 mo.:						6.73
aroma	6.56	6.83	6.40	6.85	6.52		6.48	6.20	6.62	.34 ^f	6.37	
flavor	6.58	6.73	6.72	6.45	6.53		5.83	6.20	6.47	.54 ^f	6.90	
texture	6.92	7.33	7.02	7.20	6.92		6.33	6.62	6.5	.46 ^f		

(cont.)

Table 14 (cont.)

Condition. F/R ^a	Product Number ^a										Std.dif. 2 cans ^b	Mean <u>b</u>
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
<u>18 Months:</u>												
Std.dev., judges:												
aroma	1.11	.99	1.00	.91	1.67	1.32	1.25	1.18	1.49	1.46	1.26	
flavor	1.20	1.29	1.35	1.72	1.50	1.67	1.74	1.41	1.48	1.77	1.52	
texture	1.24	1.20	1.18	1.19	1.58	1.63	1.52	1.42	1.46	1.55	1.41	

^aItems CD1, CD3, CD5, CD8 are crackers; CD2, CD4, CD6, CD7 are biscuits; CD9, CD10 are bulgur wafers.

^bMeans for 6 months also include all 10 items.

^cSignificant differences (based on variance of duplicate cans) for products in storage conditions may be estimated as standard difference X 1.58.

^dSignificant differences (based on can variance) for storage conditions in each product may be estimated as standard difference X 1.73.

^eSignificant difference for storage condition means based on total variance.

^fSignificant difference for product means, based on total variance.

TABLE 15
HEPCHIC RATINGS FOR AROMA, FLAVOR AND PALATABILITY OF SHELTER RATIIONS
(Hedonic 9-1 scale; means for 25 judges of two cans)

Condition of F/R.h.	Product Numbers ^a										Std. dif. 2 cans/bc	Mean b
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
Initial:												
aroma	5.58	5.80	5.94	6.10	5.58	6.24	6.54	6.28	5.30	5.60	.29	6.00
flavor	5.54	7.62	6.10	6.46	5.88	6.20	6.60	6.06	5.52	5.68	.32	6.17
palatability	5.70	7.10	6.30	6.40	6.06	5.92	6.90	6.38	5.36	5.64	.27	6.21
12 Months:												
100/80:												
aroma	5.82	5.64	5.20	5.60	5.26	5.76	5.46	5.40	4.08	5.08	.37	5.33
flavor	6.08	5.98	5.40	5.88	5.34	5.92	5.46	5.24	4.38	5.22	.34	5.49
palatability	6.26	6.36	5.94	6.20	5.62	6.00	6.06	5.48	4.80	5.32	.37	5.80
100/57:												
aroma	5.88	5.58	5.20	5.54	5.34	5.84	4.96	5.50	4.44	5.08	.42	5.34
flavor	5.96	5.92	5.50	5.74	5.32	5.96	4.98	5.46	4.86	5.26	.36	5.50
palatability	6.12	6.32	6.28	6.26	5.60	5.98	5.62	5.78	5.16	5.50	.38	5.86
70/80:												
aroma	5.88	6.62	6.08	6.04	5.38	6.28	5.78	5.70	4.56	4.96	.39	5.73
flavor	5.54	6.58	6.10	6.26	5.66	6.20	5.96	5.64	5.30	5.28	.28	5.85
palatability	5.88	6.92	6.26	6.26	5.64	6.00	6.44	5.80	5.28	5.46	.36	5.99
70/57:												
aroma	5.94	6.66	6.02	6.08	5.44	6.18	6.00	5.78	4.50	5.02	.33	5.76
flavor	5.50	6.68	6.16	6.50	5.64	6.04	6.00	5.64	4.92	5.54	.39	5.86
palatability	5.82	6.80	6.42	6.70	5.86	5.70	6.46	5.72	5.10	5.34	.34	5.99

(con't)

Table 1> (cont)

Condition °F/g r.h.	Product Numbers ^a										Std. dif. 2 cans/bc	Mean b
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
<u>12 Months:</u>												
40/57:												
aroma	6.22	6.46	6.34	6.02	5.64	6.12	5.98	6.04	4.80	5.32	.36	5.89
flavor	6.02	6.96	6.28	6.36	5.76	6.06	5.86	5.90	5.36	5.56	.21	6.01
palatability	6.06	6.78	6.54	6.44	5.74	5.90	6.26	6.04	5.40	5.54	.31	6.09
O/arb:												
aroma	5.94	6.48	6.34	6.30	5.26	6.14	6.26	5.98	4.60	5.16	.38	5.85
flavor	5.82	6.96	6.38	6.48	5.56	6.10	6.30	5.66	5.02	5.46	.30	5.97
palatability	5.88	6.92	6.52	6.44	5.58	6.14	6.46	5.74	5.24	5.38	.40	6.03
Std. dif., 2 cans: ^d												
aroma	.53	.18	.24	.52	.29	.39	.43	.32	.32	.40	.38	.18 ^e
flavor	.36	.27	.12	.25	.29	.29	.34	.40	.20	.48	.31	.19 ^e
palatability	.34	.21	.20	.53	.33	.33	.51	.38	.12	.46	.36	.21 ^e
Mean, 12 mo.:												
aroma	5.95	6.24	5.86	5.93	5.39	6.05	5.74	5.73	4.50	5.10	.24 ^f	5.65
flavor	5.82	6.51	5.97	6.20	5.55	6.05	5.76	5.59	4.97	5.39	.26 ^f	5.78
palatability	6.00	6.72	6.33	6.38	5.67	5.95	6.22	5.76	5.16	5.42	.25 ^f	5.96
<u>18 Months:</u>												
100/80:												
aroma	5.30	5.50	5.14	5.76	5.16			5.98	5.08	4.94	.27	5.72
flavor	5.26	5.68	5.32	5.68	5.30			5.50	5.14	5.14	.26	5.87
palatability	5.58	6.18	5.96	6.10	5.56			5.72	5.24	5.32	.31	5.93
100/57:												
aroma	5.64	5.48	5.00	5.74	5.04			6.10	4.82	5.06	.37	5.93
flavor	5.63	5.82	5.50	5.64	5.18			5.74	4.98	5.20	.28	5.78
palatability	5.80	6.14	5.92	6.02	5.44			5.98	5.02	5.08	.24	5.89

(cont.)

(cont)

Table 15 (cont)

Condition °F/g r.h.	Product Number ^a										Std. dif. 2 cans bc	Mean b
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
18 Months:												
6 Months:												
(cor. t)												
70/80:												
aroma	5.78	5.28	5.94	6.22	5.16			6.06	5.38	5.24	.37	6.05
flavor	5.30	5.56	6.22	6.18	5.42			6.06	5.44	5.46	.49	5.99
palatability	5.71	5.70	6.46	6.38	5.43			6.16	5.30	5.34	.32	6.01
70/57:												
aroma	5.94	5.12	5.94	6.24	5.52			6.14	5.20	5.10	.22	5.99
flavor	5.76	5.52	6.32	6.02	5.52			6.00	5.48	5.18	.33	5.99
palatability	6.10	5.64	6.38	6.30	5.56			6.14	5.46	5.30	.39	6.04
40/57:												
aroma	5.82	6.38	5.94	6.22	5.36			6.10	5.26	5.36	.29	6.10
flavor	5.56	6.58	6.18	6.22	5.38			5.80	5.74	5.66	.34	6.07
palatability	5.72	6.58	6.24	6.38	5.44			6.00	5.50	5.38	.24	6.07
0/amb:												
aroma	6.02	6.30	6.26	6.36	5.50			6.28	5.40	5.38	.32	6.11
flavor	5.70	6.62	6.44	6.48	5.70			6.08	5.78	5.76	.47	6.01
palatability	5.88	6.58	6.44	6.48	5.66			6.24	5.54	5.52	.41	6.05
Std. dif., 2 cans: ^d												
aroma	.39	.32	.23	.29	.20			.21	.26	.37	.30	.15 ^e
flavor	.38	.29	.26	.19	.18			.16	.26	.43	.39	.24 ^e
palatability	.32	.23	.19	.24	.10			.21	.22	.33	.33	Nse
Mean, 18 mo.:						mean						
aroma	5.75	6.01	5.70	6.09	5.29	(6 mo.):		6.11	5.19	5.18	.19 ^f	6.02
flavor	5.53	6.30	6.00	6.04	5.42			5.86	5.43	5.40	.33 ^f	5.95
palatability	5.80	6.50	6.23	6.24	5.52			6.04	5.34	5.32	.23 ^f	6.01

(cor't)

Table 1, (cont.)

Condition °F/g r.h.	Product Numbers ^a										Std.dif. 2 cansbc	Mean b
	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8	CD9	CD10		
18 Months:												
Std.dev., judges:												
aroma	1.41	1.24	1.32	1.35	1.56	1.41	1.31	1.24	1.79	1.58	1.43	
flavor	1.62	1.32	1.45	1.49	1.64	1.50	1.46	1.40	1.82	1.64	1.54	
palatability	1.66	1.37	1.42	1.48	1.73	1.64	1.45	1.45	1.85	1.76	1.59	

^aItems CD1, CD3, CD5, CD8 are crackers; CD2, CD4, CD6, CD7 are biscuits; CD9, CD10 are bulgur wafers.

^bMeans for 6 months also include all 10 items.

^cSignificant differences (based on variance of duplicate cans) for products in storage conditions may be estimated as standard difference $\times 1.58$.

^dSignificant differences (based on can variance) for storage conditions in each product may be estimated as standard difference $\times 1.73$.

^eSignificant difference for storage condition means based on total variance.

^fSignificant difference for product means, based on total variance.

storage differences, standard differences between duplicate cans, and relative lack of agreement among judges scoring different attributes and different products, are seen in Table 15.

III.A.5.c. Correlations of palatability ratings with objective measurements (Table 16).

With Hunter L. In general, L values were higher at higher temperatures, which also tended to be associated with lower palatability scores. Hence it was not surprising that most individual L-vs-palatability correlations were negative (i.e., the lighter samples within each product rated lower in palatability). The exceptions were cracker CD1 and wafer CD9 (6 months), both considered too dark, with lighter samples slightly preferred even though stale. It is to be noted, however (Table 16), that group correlations were positive, excepting wafers at 12 months, very stale. As groups, with storage effects thus being equalized, lighter products received somewhat higher ratings.

With Hunter "a". Relationships between Hunter "a" or redness value and palatability ratings were generally the reverse of those with Hunter L, which means they followed the same pattern. Samples at higher temperatures tended to fade, hence lower "a" values for the more stale or rancid samples which thus received lower scores (+ correlation). With groups, however, "redder" products were scored lower (- correlation), again excepting the wafers in which faded samples were quite stale.

With Hunter "b". Hunter "b" or yellowness values, which are not given with the other color values in Table 8, exhibited rather limited ranges within products, and as seen in Table 16, varied quite a bit in respect to correlations with palatability. As higher "b" values are often associated with slight browning, however, the negative sign for all group correlations is at least in accordance with the general preference for lighter products.

With Hunter a/b. As reduction in a/b value is a usual accompaniment of fading of lighter products, the agreement among the a/b and the correlations follows the general color-vs-rating pattern.

With fracture strength. The prevalent relationship was apparently a slight preference for samples having somewhat higher fracture strength, as these were usually described as crisp instead of tough. Exceptions, and the predominant lack of significance of the correlations, may be noted in Table 16.

With moisture content. No logical pattern was observed in correlations of palatability with moisture content.

TABLE 16
CORRELATIONS OF PALATABILITY MEAN RATINGS WITH OBJECTIVE MEASUREMENTS
(r, simple correlation coefficients)

Products	With Hunter Color Values			Fracture Strength	Moisture Content	Headspace Oxygen	Rancidity Values	
	L	"a"	"b"				P.V.	F.F.A.
<u>6 Months:</u> ^a								
biscuits:								
total	+ .294 ^b	- .328 ^b	- .382	+ .045	+ .011	+ .395 ^c	+ .156	- .185
crackers:								
CD8	- .504	+ .541	- .055	- .021	- .571 ^b	+ .553	- .252	- .239
total	+ .194	- .203	- .098	+ .302 ^b	+ .341 ^b	+ .177	- .144	+ .238
wafers:								
CD9	+ .094	- .212	- .565	+ .196	- .303	+ .816 ^c	+ .132	- .666 ^b
CD10	- .576 ^b	+ .524	- .087	+ .055	+ .062	+ .563	- .386	- .166
total	+ .017	- .001	- .040	+ .085	- .015	+ .686 ^c	+ .069	- .367
<u>12 Months:</u>								
biscuits:								
CD2	- .659 ^b	+ .745 ^c	- .329	+ .224	+ .055	+ .916 ^c	- .846 ^c	- .696 ^b
CD4	- .377	+ .164	- .175	+ .282	+ .003	+ .289	- .453	- .378
CD6	- .014	+ .159	+ .007	- .320	- .452	- .052 ^b	+ .207	+ .215
CD7	- .439	+ .115	+ .153	- .111	- .371	+ .645 ^b	- .354 ^b	- .475
total	+ .276	- .341 ^b	- .550 ^c	- .118	- .152	+ .443 ^c	- .326	- .021
crackers:								
CD1	+ .231	- .465 ^b	- .015	+ .389	- .168	- .410	+ .624 ^b	+ .300 ^b
CD3	- .667 ^b	+ .596 ^b	+ .501	+ .345	+ .192	+ .713 ^c	- .571	- .668 ^b
CD5	- .049	- .060	- .231	+ .278	- .015	+ .161	- .156	- .058
(con't)								

(cont)

Table 16 (cont.)

Table 16 (cont.)									
Products	With Hunter Color Values				Fracture Strength	Moisture Content	Headspace Oxygen	Rancidity Values	
	L	"a"	"b"	a/b				P.V.	F.F.A.
<u>12 Months:</u>									
crackers:									
CD8	-0.019	+0.2	+0.391	+0.324 ^c	+0.413	+0.308	+0.311	-0.350	-0.635 ^b
total	+0.317 ^b	-	-0.357 ^b	-0.460 ^c	+0.026	+0.276	+0.132	+0.051	+0.021
wafers:									
CD9	-0.251	+0.432	-0.026	+0.427	+0.846 ^c	-0.699 ^b	+0.606 ^b	+0.236	-0.620 ^b
CD10	-0.075	+0.125	-0.347	+0.190	-0.196	+0.007	+0.078	+0.022	-0.073 ^c
total	-0.532 ^c	+0.544 ^c	-0.542 ^c	+0.571 ^c	-0.163	-0.599 ^c	+0.338	-0.145	-0.515 ^c
<u>18 Months:</u>									
CD2	-0.478 ^b	+0.413	+0.566	+0.453	+0.116	+0.409	+0.729 ^c	-0.828 ^c	-0.690 ^b
CD4	-0.636 ^b	+0.527	+0.183	+0.535	-0.447	+0.345	+0.550	-0.763 ^c	-0.650 ^b
CD1	-0.058	+0.205	+0.061	+0.189	-0.505	+0.041	+0.014	-0.338 ^b	-0.407
CD3	-0.789 ^c	+0.767 ^c	+0.584 ^b	+0.776 ^c	+0.303	-0.215	+0.807 ^c	-0.649 ^b	-0.900 ^c
CD5	-0.148	+0.007	-0.246	+0.084	-0.320	+0.326	+0.282	-0.164	-0.343

a) Completes "Products" section of Table 15, Annual Report #1.

b) Significant at the 5% level of probability.

c) Significant at the 1% level of probability.

With headspace oxygen. The general correlation of higher oxygen with higher ratings was expected, as samples at lower temperatures absorbed less oxygen and remained fresh or only slightly stale. The single exception at 12 months, as at 6 months, was cracker CD1, a scorched product in which staleness was not so pronounced in flavor effects, and in which headspace oxygen range was generally lower than in most other crackers and biscuits. Biscuit CD6 also had a low range, and a very low, though positive, correlation value.

With peroxide values. Correlations with palatability ratings were somewhat variable, but most of the large values and all significant values, again excepting cracker CD1, were negative. This was the expected pattern, as actively oxidizing samples normally receive lower scores.

With free fatty acids. As with peroxides, high and significant correlations were generally negative. Group differences were less pronounced than sample differences (i.e., within-product correlations), indicating the influence of the temperature effect. It was noted that a greater number of both peroxide and free fatty acid correlations were significantly negative at 12 months than at 6 months, and at 18 months than at 12 months. Apparently the oxidation and hydrolysis patterns, with accompanying staleness or rancidity, are fairly definitely established.

III.B. The Carbohydrate Supplements

Data and comments included in this report will serve to describe essential details of methodology, as well as to establish initial values for examination of carbohydrate supplements (hard candies, lemon and cherry flavors) CD11, CD12, and CD13. These items, which were received around 1 February 1964, before completion of contract negotiations, were examined and stored with initial date 27 Mar 1964.

III.B.1. Construction of packages.

Each can contained a banded or bagged package of 20 (specified number) 300 X 500 bags (3 X 5 inches internal size), placed on top of the candy. These bags were made, according to specifications, by cutting out a 308 X 1004 (3½ X 10¼ inches) strip of kraft-backed plastic film, folding 5 inches over with plastic side in, and running an 04 (¼ inch) seam along the two 5-inch edges, thus leaving an 04 lip at the open top.

As cans were opened for initial examination, bag seams and fabric were tested by cutting out a 100 X 308 cross section from the center of each flat bag and then cross-cutting one side to form a 100 X 600

strip including 1-inch sections of both seams. One end of the strip was attached to a fixed clamp and a 1-pound weight gently suspended from the other end for exactly 5 minutes at 73°F/50% r.h. Seam separations were recorded to the nearest 01 (1/16th inch), and any tearing of fabric was noted.

Initial inspection of bags yielded the following results:

<u>Code</u>	<u>Packing</u>	<u>Bags Per</u> <u>5 cans</u>	<u>Internal Size</u> <u>(can code)</u>	<u>Lip Width</u> <u>(can code)</u>	<u>Seam Width</u> <u>(can code)</u>	<u>Seam Test</u> <u>separated</u> <u>(can code)</u>	<u>Results</u> <u>fabric</u> <u>torn</u>
CD11	kraft band	99	300 X 500	91 @ 04 8 @ 03	195 @ 04 3 @ 03	190 none 8 by 01	none
CD12	kraft band	94 good 1 holes 5 un- sealed	86 @ 300 X 500 9 @ 300 X 413 5 @ open X 500	85 @ 04 9 @ 07 4 @ 03 2 @ 02	152 @ 04 5 @ 12 20 @ 07 8 @ 03 8 @ 02 2 @ 01 5 @ 00	191 none 4 by 01	none
CD13	plastic bag	100	300 X 508	all 04	all 04	186 none 5 by 02 9 opened	none

III.B.1.b. Condition of products.

The candies were evaluated in 4 "size-groups"; i.e., whole pieces, chipped pieces (75% or more remaining), broken pieces (pieces between 75% and 8-mesh in size), and loose sugar (material passing 8-mesh screen, including bits of candy). Net product weight was estimated as gross weight less loose sugar. Whole pieces were weighed and converted to count by applying average count-per-pound values, chipped pieces were counted, broken pieces were converted to count by removing sufficient weight to restore chipped pieces to original weight and applying count-per-pound values to remaining material. Lemon and cherry flavors, supposedly mixed in 1:1 ratio, were evaluated separately in sampling, recombined where feasible in percentage calculations.

Results of initial examination, 5 cans of each product, were as follows:

2210.8 #II

	<u>CD11</u>		<u>CD12</u>		<u>CD13</u>	
	<u>n</u>	<u>std.dev.</u> 5 cans	<u>mean</u>	<u>std.dev.</u> 5 cans	<u>mean</u>	<u>std.dev.</u> 5 cans
loose sugar, %	2.45	1.78	.66	.20	1.08	.22
net weight, lbs	34.3	.3	35.8	.1	33.9	.1
count per lb	119.9	4.4	89.2	.7	88.1	.7
lemon, count %	41.8	6.7	49.0	1.9	49.3	1.3
normal, "	83.76	3.84	88.20	4.04	90.03	1.14
unsanded, "	.13	.14	.61	.89	.03	.05
off color, "	.04	.04	.01	.02	.16	.10
clumped, count %	1.69	1.13	.13	.07	.46	.13
number/clump	2.28	-.28 +1.48	2.10	-.10 +.90	2.04	-.04 +.96
off shape, count %	6.80	.95	.51	.31	.97	.13
chipped pieces, "	4.93	.97	10.30	3.92	5.27	.81
broken pieces ^a , "	2.65	.84	.24	.18	3.08	.67

^aCalculated as count % equivalent remaining after
chipped pieces were restored to full weight.

III.3.2.a. Sensory quality scores, appearance and color.

Five judges scored candy from each of 5 cans, with both lemon
and cherry flavors in each sample, using the customary sensory quality
scale from 10 = excellent to 1 = poor. Average scores were as follows:

	<u>CD11</u>	<u>CD12</u>	<u>CD13</u>
Appearance:			
mean	8.04	8.20	8.05
std.dif., cans	.42	.20	.28
Color:			
mean	8.68	8.28	8.35
std.dif., cans	.26	.26	.36

Comments included:

Appearance - generally good, some unevenness of shape and sanding,
particularly in the powdery appearance of CD12

Color - generally good, CD12 and CD13 slightly pale and
uneven

III.B.2.b. Hunter color values.

Determined with Color and Color Difference Meter, wide field illumination; Standard for lemon: NBC 801 (maize, SBC-35), $L = 73.8$, $a = 1.4$, $b = 31.4$; Standard for cherry: NBC 994 (kitchen red, SKC-70), $L = 28.7$, $a = 49.5$, $b = 18.1$. Samples were prepared by passing through a motor-driven food chopper with 8-hole plate and screening through 4-mesh and 12-mesh screens, color material being that which rode 12-mesh.

	<u>L</u>	<u>a</u>	<u>b</u>	<u>a/b</u>
<u>Lemon:</u>				
CD11: mean	67.2	-5.7	36.6	-.156
std.dif., cans	3.1	3.0	1.5	.075
CD12: mean	67.4	1.3	34.3	.038
std.dif., cans	2.4	2.9	.6	.082
CD13: mean	72.4	-10.0	30.9	-.324
std.dif., cans	1.1	.8	.7	.023
<u>Cherry:</u>				
CD11: mean	39.6	15.7	5.4	2.903
std.dif., cans	2.6	2.4	.8	.679
CD12: mean	59.0	14.7	5.3	2.755
std.dif., cans	1.1	1.6	1.2	.299
CD13: mean	46.3	9.1	3.1	2.910
std.dif., cans	.6	1.9	.5	.669

In lemon, CD13 was somewhat brighter than the others (higher L value) and a greener shade than CD11 (higher -a value). CD12 was a slightly orange yellow (+a instead of -a). Shades of yellow are indicated by a/b values.

In cherry, CD12 was a brighter and slightly "yellowish" red (higher L, lower a/b), while CD13 was somewhat brighter and about the same shade as CD11, but a "weaker" red (higher L, same a/b, lower a/b).

III.B.3. Fracture strength. - Not applicable to candies.

III.B.4.a. Headspace oxygen in cans. - Not applicable to candies.

III.B.4.b. Moisture Content.

Samples were broken up by passing through a motor-driven food chopper, and then through a 20-mesh screen. Moisture was determined as loss of weight of ca 5 grams after heating 20 hours at 70°C, ca 30 mm pressure.

Results were as follows (percent moisture):

	<u>CD11</u> lemon & cherry	<u>CD12</u> lemon & cherry	<u>CD13</u> lemon	<u>CD13</u> cherry	<u>CD13</u> mean
mean	1.35	1.34	1.74	1.27	1.50
std.dif., cans	.34	.05	.57	.03	.05

III.B.4.c. Rancidity values. - Not applicable to candies.

III.B.4.d. pH values.

For the purpose of storage comparisons, pH values were determined by dissolving 1 weight candy in 3 weights deionized water and reading with a Beckman Zeromatic meter. Results were:

	<u>CD11</u>	<u>CD12</u>	<u>CD13</u>
mean	6.55	6.70	6.75
std.dif., cans	.10	.15	.10

Differences or changes in pH may reasonably be expected to influence rate of sucrose inversion in storage.

III.B.4.e. Sugar contents.

Reducing sugars expressed as dextrose and invert sugar expressed as sucrose were determined by A.O.A.C. methods. The original 25-gram samples were taken during processing of candy for moisture determination, to prevent possible errors in calculating sugars on a dry-candy basis, and aliquants of these were sub-sampled as needed for determinations.

Results were as follows:

	<u>Dextrose, %</u>			<u>Sucrose, %</u>		
	<u>CD11</u>	<u>CD12</u>	<u>CD13</u>	<u>CD11</u>	<u>CD12</u>	<u>CD13</u>
mean	19.40	16.25	17.40	62.80	65.15	62.95
std.dif., cans	.57	.15	.15	.78	.57	.71

Differences between lemon and cherry flavors were only slightly greater than can differences. Should flavor differences develop with storage, they will be reported separately.

III.B.5.a. Sensory quality scores, aroma, flavor and texture.

These qualities were scored with those given in III.B.2.a., above. Average results were as follows:

	<u>CD11</u>	<u>CD12</u>	<u>CD13</u>
Aroma:			
mean	7.36	7.60	7.80
std.dif., cans	.24	.20	.24
Flavor:			
mean	7.92	7.32	7.85
std.dif., cans	.16	.33	.15
Texture:			
mean	8.24	8.56	8.20
std.dif., cans	.24	.13	.00

Comments included:

- Aroma - lemon good in CD11 and CD12, too weak in CD13; cherry good in CD13, artificial and unpleasant in CD11 and CD12
- Flavor - generally good, lemon weak in CD11, cherry flat and artificial in CD12, both slightly weak in CD13
- Texture - typical hard candy, slightly uneven brittleness in CD11, sanding sugar coarse in CD13

III.B.5.b. Hedonic ratings, aroma, flavor and palatability.

As can be seen, differences were relatively minor in sensory scoring by the 5 judges of sections III.B.2.a. and III.B.5.a. (above), composite samples were presented to the 25 judges for hedonic ratings. Results were as follows:

	<u>CD11</u>	<u>CD12</u>	<u>CD13</u>
Aroma:			
mean	6.88	6.76	7.04
std.dev., judges	1.11	1.34	1.22

	<u>CD11</u>	<u>CD12</u>	<u>CD13</u>
Flavor:			
mean	7.76	7.24	7.76
std.dev., judges	.65	1.43	.77
Palatability:			
mean	7.48	7.40	7.76
std.dev., judges	.99	1.30	.91

Comments were almost identical with those given by the 5 judges of sensory quality (above).

III.B.5.c. Correlations, palatability with objective measurements. - Not applicable at this stage.